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TRANSACTIONS

OF THE

AMERICAN INSTITUTE

OF

ELECTRICAL ENGINEERS,

CORNELL UNIVERSITY
DEC 16 1886
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VOL. I.

MAY, 1884—OCTOBER, 1884.

NEW YORK CITY:
PUBLISHED BY THE INSTITUTE,
AT THE OFFICE OF THE SECRETARY,
9 MURRAY ST.

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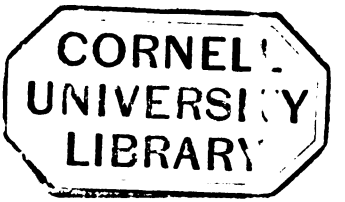

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THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

The first steps toward the formation of the society were taken in April, 1884, when the following circular was issued for signatures, by Mr. N. S. Keith, of New York:

The rapidly growing art of producing and utilizing electricity has no assistance from any American national scientific society. There is no legitimate excuse for this implied absence of scientific interest, except that it be the short-sighted plea that everyone is too busy to give time to scientific, practical and social intercourse, which, in other professions, have been found so conducive to advancement.

The American Civil, and Mechanical and Mining Engineers societies, which have been so prosperous and of such great advantage to their members, are good examples.

An International Electrical Exhibition is to be held in Philadelphia next autumn, to which many of the famous foreign electrical savants, engineers and manufacturers will be visitors; and it would be a lasting disgrace to American electricians, if no American national electrical society was in existence to receive them with the honors due from their co-laborers of the United States.

It is proposed to organize THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, somewhat after the model of the American Civil, Mechanical and Mining Engineers' societies or institutes. These societies hold yearly three or four meetings, lasting three or four days each time, at various suitable places throughout the country, at which meetings the members assemble, read and discuss papers and matters relating to their trades or professions, and at the same time enjoy pleasant, personal, social intercourse, all of which is conducive to improvement and advancement in ideas, theories, practice, business and good-fellowship. The success of these societies, as well as of the various foreign electrical societies, makes it seem probable that those persons who are interested in our electrical, scientific, educational, manufacturing, telegraphic, telephonic and like concerns, as well as the users of electrical appliances generally, will find it to their advantage, personally and collectively, to establish, support, work for, and generally aid our proposed society.

It is proposed to make electrical engineers, electricians, instructors in electricity in schools and colleges, inventors and manufacturers of electrical apparatus, officers of telegraph, telephone, electric light, burglar-alarm, district messenger, electric time, and of all companies based upon electrical inventions, as well as all who are inclined to support the organization for the common interest, eligible to membership.

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It is proposod to make the yearly dues about ten dollars, and to print in book form the papers, discussions and transactions at the meetings for distribution among the members without further expense. As with other societies these will be worth more than the annual dues. Affiliations with sister societies, a museum, library, original research, protection from unfavorable legislation, settlements of disputed electrical questions, exchange of volumes of transactions with foreign and other electrical and scientific societies, a journal of abstracts of papers read before other societies, or published in other journals, etc., etc., are all proposed.

The subscribers hereto hereby extend an invitation to all those persons who are eligible to membership to meet them in New York City at a place to be announced hereafter, on TUESDAY, THE 13TH DAY OF MAY, 1884, for the purpose of organizing the proposed national electrical society upon substantially the basis herein set forth.

This document was at once signed by a large number of electricians, capitalists and others connected with electrical enterprises or interested in the advancement of electrical science. It was deemed advisable, therefore, to hold a preliminary meeting, and the signers assembled at the rooms of the American Society of Civil Engineers, New York, on April 15, as founders of the proposed society.

Mr. N. S. Keith called the meeting to order and nominated Mr. Jos. P. Davis, Vice-President of the Metropolitan Telegraph and Telephone Company, as chairman of the meeting. After Mr. Davis took the chair, Mr. Keith was elected temporary secretary.

Mr. T. H. Delano offered a series of resolutions as to name, objects, membership, dues, management, committees, etc. On motion of Mr. Wm. A. Hovey, after some debate, the resolutions and the whole scheme of organization were referred to a committee of five, to be appointed by the chair, with instructions to call a meeting to hear and act upon its report. The chair afterward appointed the committee, consisting of the following gentlemen:

W. A. Hovey, President Merchants' Electric Light Company, Boston.

N. S. Keith, Electrical Engineer.

George A. Hamilton, Electrician, Western Union Telegraph Company.

Wm. H. Eckert, General Superintendent of the Metropolitan Telephone and Telegraph Company.

Geo. L. Beetle, Western Electric Company.

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After a vote of thanks to the American Society of Civil Engineers, and to Mr. John Bogart, the Secretary of that society, for the use of its rooms, the meeting adjourned, subject to the call of the committee.

The next meeting was held at the same place on May 13. Mr. Jos. P. Davis, chairman of the previous meeting, presided. The minutes of the meeting of April 15 were read and approved. The Committee on Organization reported that they had completed a proposed set of rules for the government of the Institute, and had nominated a sufficient number of persons to fill the offices created. The rules were then read, and adopted.* The chairman appointed Messrs. Sargent, Delano, and Ross scrutineers of the ballots for officers. The election was then proceeded with, and resulted as follows: †

FOR PRESIDENT:

DR. NORVIN GREEN, New York City.

FOR VICE-PRESIDENTS:

PROF. A. GRAHAM BELL, Washington, D. C.
PROF. CHARLES R. CROSS, Boston, Mass.
THOMAS A. EDISON, New York City.
GEO. A. HAMILTON, New York City.
CHAS. H. HASKINS, Milwaukee, Wis.
FRANK L. POPE, Elizabeth, N. J.

FOR MANAGERS:

CHARLES F. BRUSH, Cleveland, O.
WILLIAM H. ECKERT, New York City.
STEPHEN D. FIELD, New York City.
PROF. ELISHA GRAY, Chicago, Ill.
PROF. EDWIN J. HOUSTON, Philadelphia, Pa.
M. L. HELLINGS, Key West, Fla.

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* See Appendix.

† At the first meeting of the Council, held May 20, the terms of offices were determined by lot: *Vice-Presidents* to hold office for one year, Profs. Bell and Cross; for two years, Messrs. Edison and Hamilton; for three years, Messrs. Pope and Haskins. *Managers* to hold office for one year, Messrs. Jones, Hillings, Eckert, and Smith; for two years, Profs. Trowbridge and Gray, and Messrs. Field and Vail; for three years, Prof. Houston and Messrs. Brush, Weston, and Prescott.

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FRANK W. JONES, New York City.
GEORGE B. PRESCOTT, New York City.
W. W. SMITH, Indianapolis, Ind.
PROF. W. P. TROWBRIDGE, New York City.
THEODORE N. VAIL, Boston, Mass.
EDWARD WESTON, Newark, N. J.

FOR TREASURER:

ROWLAND R. HAZARD, New York City.

FOR SECRETARY:

NATHANIEL S. KEITH, New York City.

The following communication was then read:

"United States Patent Office,"
Washington, D. C., May 12th, 1884.

"N. S. KEITH, Esq., *Secretary.*

"My Dear Sir:

"I find at this late day that it will be impossible for me to be with you to-morrow at the organization of the Institute of Electrical Engineers, owing to sickness in my family. It was my especial desire to be with you during this meeting and to call the attention of the members to the existing condition of the Patent Office, in relation to inventors, manufacturing interests, and in general to the advanced position among the nations of this generation, owing more than for any other reason to our liberal patent system. I wanted particularly to call attention to the Platt Bill, introduced into the Senate by Senator Platt, and providing for a Patent Office Department entirely distinct from over-ruling authority other than the Commissioner of Patents. You will confer a special favor upon me by bringing this matter to the attention of the Institute, and asking them to call upon Congress to pass the bill. It is a burning shame upon our national reputation that Congress should have permitted inventors to pay into the United States Treasury $2,500,000 over and above the expense incurred in examining and issuing patents; but such is the fact. During the past year this Bureau deposited to its credit over $471,000 more than was expended in the granting of patents for the current year. Is not this taxation without representation, and

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are inventors to sit idly by and submit to this while the Patent Bureau is crowded out of its building by other branches of the Interior Department?

"I transmit herewith a report to Congress by the Commissioner concerning the condition of the work in the Patent Office. I would be glad if you would call attention to my report therein in relation to the class of electricity, and beg to advise you that since it was written two of my assistants have resigned, and I am now 600 cases behind hand; so that were you to file an application to-day, it would be four months before I should reach it. It is simply absurd that the Congress of this great country does not have the foresight to realize that by thus hampering this Bureau they are throttling the onward progress of an advanced civilization and unjustly robbing the inventor of funds which the founders of the Constitution never intended should be so diverted. Every dollar taken from the inventor by this direct taxation should be invested as was intended, so as to give him such an examination as the law calls for, and to insure an expeditious examination of his application. I desire also to call attention to the fact that serious attempts have been made by Western Congressmen to shorten the life of American patents, but fortunately such attempts have all so far failed. Please give this matter your honest attention, and impress upon the Society our desire as a Bureau to be placed on an independent footing, free from all trammel, and where we can use the funds deposited by inventors exclusively for the purposes for which they are designed. It is not designed to make the head of such a department a cabinet officer, nor is such proposition desirable. Only let us be so situated that if we desire additional room, additional force or anything which will materially aid us in the transaction of the business of the Bureau we shall not be humiliated by being dictated to as to how we shall use our facilities or dispose of funds designed for a special purpose. I regret exceedingly that I cannot be with you to lay this matter before your meeting, but I feel sure that with these few suggestions you will do the proper thing.

"Pardon this long letter, but rest assured that it is only an earnest desire to see justice done both to this Bureau and to inventors that prompts me to action.

"Consider me in hearty accord with the Institute.

"I remain very respectfully yours, C. J. KINTNER,

Ex'r. Class Electricity, U. S. Patent Office."

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Mr. Frankland Jannus, of Washington, D. C., stated some of his experience in his professional efforts to secure patents, especially in the class of electricity; he advocated united effort to influence Congress to do justice to inventors.

The meeting then passed the following resolution, which was offered by Prof. W. P. Trowbridge: "That the influence of the members and associates of the American Institute of Electrical Engineers should be exerted to prevent any restriction of the rights and privileges of inventors, as they now exist under the laws, and that the Institute of Electrical Engineers earnestly desires the passage of Senator Platt's bill or its equivalent, in order that the work of the Patent Office may be put on a more efficient footing."

The meeting then passed the following resolution, which was offered by Mr. George S. Bowen: "*Resolved*, That the chair appoint a committee of three who shall take such action as they may deem proper, with a view to calling the special attention of Congress to the needs of the Patent Office, especially in regard to the class of electricity."

Mr. Isaac Trumbo, of San Francisco, made some remarks on the state of electric lighting on the Pacific slope, and stated that he had been investigating various systems of lighting for use in the West.

The meeting then passed the following resolution, which was offered by Gen. C. H. Barney:—"*Resolved*, That the thanks of this meeting be tendered to the Committee on Organization, for the efficient manner in which they have performed their duties."

The meeting then passed the following resolution: "That the thanks of this meeting be tendered to the American Society of Civil Engineers for the kind offer of the use of the rooms of this Society for meetings until such time as the Institute may secure rooms for this purpose."

On motion the meeting then adjourned, subject to the call of the Council.

The following is the text of the communication to the Commissioner of Patents referred to in Mr. Kintner's letter:

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REPORTS OF EXAMINER KINTNER.

DIVISION: ELECTRICITY.

Date: March, 1884.

In conformity with your order concerning the condition of the work, necessary additional force required, etc., I have the honor to submit the following report:

New cases awaiting action, 286; oldest cases awaiting action, 88; total, 374.

Oldest new case awaiting action, November 8, 1883.

Oldest amended case awaiting action, January 14, 1884.

I have now a force of eight assistants and two clerks.

This division embraces electrical appliances pure and simple, and has grown in four years so far as to include over 6,000 patents.

Prior to July 1, 1880, there were less than 2,000 patents which disclosed any electrical appliances or apparatus whatever.

Since that time, the rapid advance made in telephony, telegraphy, electric lighting appliances, dynamo machines, etc., has placed the division foremost in the arts, and the capital invested in such inventions far exceeds what could have been anticipated.

As a result, this division is burdened with applications, and improvements are so rapid that a thorough reorganization of the classification is necessitated about once in two years.

New inventions and appliances spring up; new uses are developed, and new sub-classes are, or should be, necessarily made.

With my present force, it is quite impossible for me to devote the time to the proper care of the class and of a proper reorganization, such as should be made to guarantee accurate and exhaustive searches.

In fact, the class is growing so rapidly, that another division should be made, and I have the honor to suggest that it be formed at an early day and located in rooms adjoining those now occupied by the present division.

I have no digests of foreign patents, or of the state of the art generally, during the past ten years, the most important, indeed, in its history; nor have I, with my limited force, the time to prepare such digests.

With reference, then, to your request as to the additional force, I have to suggest that at the least four more assistants should be added to the division, and that careful and accurate digests be

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made of all electric patents, both foreign and domestic, and of publications containing electrical subjects.

To do this as it should be done, the briefs should be made by the assistants in charge of the respective sub-classes. I am growing more and more aware of the incompleteness of our facilities, as the art advances from year to year, and in order to insure the grant of valid patents, the course here indicated should be pursued.

There is no other art embraced under our patent system which could be so thoroughly digested, and which would more fully repay for such work, for the reason that it has grown up almost entirely within the past quarter of a century.

With proper digests the class would soon be placed in such condition that a more limited force could control it.

As it is now, we are getting deeper in the mire each year; and as assistants become skilled in the state of the art there are other demands for them, and they go out of the office, carrying with them a knowledge gained only by years of research.

Since 1881 the entire *personnel* of this division has changed. Three principal examiners and four assistants have left to fill more lucrative positions outside, and the office has been placed at a disadvantage by having to educate new men to fill their places, with the probability of these men leaving at an early day.

I must again call attention to the limited rooms which this division is forced to occupy, and to the fact that the ventilation is very bad. In fact, much sickness results, and my assistants are so crowded that it is impossible to do the work required of them, either satisfactorily or with comfort.

The light is so exceedingly poor that I trust my previous suggestions concerning electric light will be carried into effect.

In response to your inquiries concerning the room, discomforts, inconveniences, etc., of this division, I beg to submit the following:

1. Numbers and location of room: 89 and 91, ground floor, F street, front; room 89, being 22 by 21 feet, and room 91, 21 by 10.

2. Eleven persons constitute the total force of the division, distributed as follows: eight in room 89, and three in room 91.

3. There are eight desks, one table, and three cases in room 89, and three desks and six cases in room 91, and the result is such an undue crowding as to very seriously impede the business of the division.

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The original drawings are all located in the hall outside the rooms, and there is no light by which they may be seen.

4. The rooms are badly ventilated, and my assistants are all forced to vacate them, at least once every day, in order that they may be thrown open and aired. The light is so bad that in two instances assistants have contracted eye diseases, which were only cured after having resigned their positions.

In 91, my own room, there is no gas, and I am obliged to use kerosene oil, which seriously vitiates the atmosphere. There is gas in room 89, and much of the time gas and oil have to be burned the entire day.

The plumbing is in bad condition, and sewer gas escapes at the wash-basin. The floor is directly upon the ground, and hence excessive dampness results.

There is much sickness and constant complaint on the part of the entire force, of headache and general indisposition.

A computation of the dimensions of room 89 shows that each person has 500 cubic feet of air to breathe; during the space of seven hours this air would be inhaled and reinhaled by each person no less than six times, allowing one cubic foot per second as a healthy respiration.

PHILADELPHIA MEETING.—SEPTEMBER-OCTOBER, 1884.

The Directors of the International Electrical Exhibition, Philadelphia, held under the auspices of the Franklin Institute, having kindly tendered to the Institute the free use of rooms in the exhibition building, so long as it should remain open, the offer was accepted by the Council, and the Secretary was authorized to make the necessary preparations and to be present during the Exhibition as the representative of the Institute.

The rooms were accordingly opened to members by Mr. Keith on September 2d, and remained open until October 11th, during which time they were visited by a great many members of the Institute and by several foreign electricians. On October 7th and 8th a meeting was held, in accordance with the rules and a call, at the Continental Hotel and at the Exhibition rooms, where the papers forming part of this volume were read and discussed.* On the invitation of the Franklin Institute, the Exhibition was also inspected by the members in a body.

*Owing to ill health, Mr. C. O. Mailloux has not been able to prepare for publication in this volume his paper on "Exploring the Field of the Dynamo-Electric Machine.

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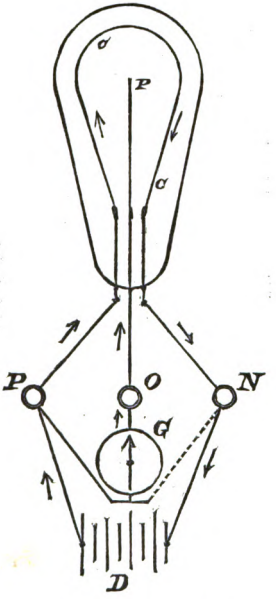
A paper read before the American Institute of Electrical Engineers, at Philadelphia, October, 1884.

NOTES ON PHENOMENA IN INCANDESCENT LAMPS.

BY PROF. EDWIN J. HOUSTON.

Prof. HOUSTON :—I have not prepared a paper, but merely wish to call your attention to a matter which, I suppose, you have all seen and puzzled over. Indeed, I wish to bring it before the society for the purpose of having you puzzle over it. I refer to the peculiar high vacuum phenomena observed by Mr. Edison in some of his incandescent lamps. I have in my hand an Edison incandescent lamp, having the same vacuum as the ordinary incandescent lamp. This one, however, has, in addition to the carbon filament, a platinum plate, or strip, that is thoroughly insulated from the filament, and supported in the manner seen between the two branches of the filament, as shown in Fig. 1.

FIG. 1.



An Edison carbon filament, *c*, *c*, is placed inside an inclosing glass case in the usual manner. A strip of platinum foil, P, is supported as shown inside the loop. The binding posts, P and N, are connected to the ends of the carbon loop, and O to one end

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of the platinum plate. P is the positive, and N the negative terminal of the electric source.

The lamp being placed in the circuit of any electrical source, as, for example, a battery, D, the current will flow in the direction indicated by the arrows. The galvanometer, G, has one of its terminals connected with the positive terminal, P, of the electrical source, and the other terminal connected with one end of the platinum strip, or plate.

P, representing the positive terminal, the current may be conceived as flowing through the filament in this manner. [Indicating.] If the ordinary current used in producing the light is passing, then no unusual effects are noticed. If, however, the current is increased, so that the incandescence of the filament is raised from its normal, say, eight candle-power, to twenty—, thirty—, forty—, fifty—, or one hundred candle-power, then the needle of the galvanometer is violently deflected by a current passing through its coils.

The question is, what is the origin of this current? How is it produced? Since we have within the globe a nearly complete vacuum, we cannot conceive the current as flowing across the vacuous space, as this is not in accordance with our pre-conceived ideas connected with high vacua. I should mention here, that if the galvanometer terminal, instead of being connected with positive, P, of the electric source, be connected with the negative, N, then we also have a current flowing through the galvanometer, but this time in the opposite direction. But in this case its amount is much less, being but about $\frac{1}{10}$ of the amount of the first current.

I have no theory to propound as to the origin of these phenomena. I make these desultory remarks merely because I wish to call your attention to the phenomena, if you have not already seen them. It is very clear as to the direction in which the current flows, when one end of the galvanometer is connected with the positive terminal, P. This I have traced by observing the direction of deflection of the galvanometer needle. The current flows, not as we might suppose, from the carbon to the platinum; it flows apparently in this direction, as if it came from the platinum. If it flowed as though it went from the carbon to the platinum, then it might be ascribed to various causes. It may be electricity flowing through empty space, which I don't think probable; or it might be the effect of what may be called electrical convection, if there is such a term. The Crookes' discharge from one of the poles might produce an electrical bombardment against

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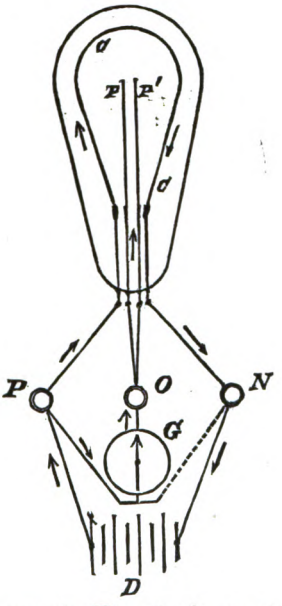
the plate, each molecule taking a small charge that might produce the effect of a current.

If we conceive, as I think most probable, a flow of molecules passing from the platinum to the carbon, then the phenomena may be readily explained as a Crookes' effect, since then we can regard a current as flowing in parallel circuit, from P, to N, through the carbon loop, and from P, through G, O, and P, to the carbon loop. But, remembering that the direction of the current is reversed, or apparently so, when the galvanometer is connected with the negative terminal, N, then the difficulty is to understand how the current there produced could possibly overcome the current from the source supplying the lamp. I should say here, however, that I am not entirely convinced from the few experiments I have tried myself, as to the actual existence of such a current. The deflection of the galvanometer needle, when connection was made with the negative terminal, being quite feeble. I am assured, however, that decided deflections have been observed.

I saw another lamp, in which two platinum plates are placed inside the lamp, but unfortunately I have not succeeded in finding the gentleman exhibiting it, so as to obtain from him an explanation of its peculiarities.

FIG. 2.



In this lamp, as shown in Fig. 2, the parts are the same as in Fig. 1, only two platinum strips, P, P′, placed parallel to each other,

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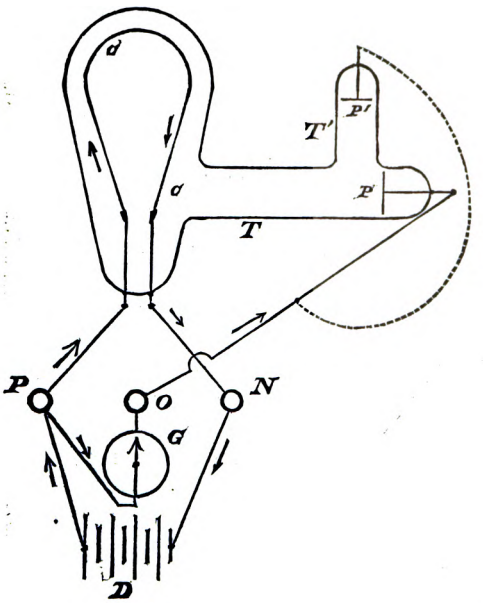
are employed. If a current is produced when the terminals, O, are connected with the galvanometer, then the phenomena is still more difficult of explanation. I believe, however, that one pole of the electrical source is always connected with the galvanometer, the other being connected with either or both of the platinum terminals. If such is the case, then the phenomena are simply modifications of the preceding.

I believe we shall find the preceding phenomena worth looking into. For my own part I am somewhat inclined to believe that we may possibly have here a new source of electrical excitement. That in some way the molecular bombardments against the platinum plate may produce an electrical current. At least, supposing it to be true that when the terminal, N, is connected with the galvanometer, the current through the galvanometer flows in the opposite direction to the current from the electrical source, it would seem that the phenomena could not be ascribed to the Crookes' effect.

FIG. 3.



Supposing, however, this opposite current out of the way, then a more careful inquiry may show the sufficiency of the Crookes' effect for the explanation of the phenomena. Indeed, an experi-

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ment Mr. Edison has made, would appear to throw no little light on the matter. Instead of placing the platinum pole, P, inside the carbon loop, it was placed in the end of a long tube, T, T′, forming a part of the lamp case. When the connections were made, as shown, with the platinum at P, so as to place it in line with the carbon, and, therefore, expose the filament to the bombardment of the molecules shot out from the platinum, the needle of the galvanometer was deflected, even though the tube, T, was surrounded by a freezing mixture. When, however, the platinum was placed at P′, in the branch tube T′, out of the direct line of the carbon, no effects were observed in the galvanometer.

I have brought this matter before you in this crude way, thinking it may be interesting, and that it might possibly elicit a discussion which would aid us in ascertaining its cause.

Mr. KEITH:—May I ask if the current always flows from the platinum plate towards the carbon?

Prof. HOUSTON:—I am not sure; I think in one case it flows from the carbon to the platinum.

Mr. KEITH:—That mystifies the matter still further.

Prof. HOUSTON:—Certainly.

Mr. KEITH:—It seems to me that there is a galvanic couple. It will be, provided that at all the times the current flows from the platinum, reaction may take place; or even if it flows from the carbon to the platinum, no matter whether constantly or not. The remarks that I was going to make are spoiled by lack of data on the subject.

Mr. PREECE:—Prof. Houston, may I ask you on what grounds you assert, or anybody asserts, that electricity flows in one direction rather than another?

Prof. HOUSTON:—Simply on the ground of its being a definite idea. I don't know that any one could prove that electricity flows more readily in one direction than another; but we have a convenient way of speaking of it as flowing from a higher to a lower potential. I think the facts would appear to warrant us in saying so. Of course, I do not know whether it is so or not. For my own opinion I would say that I think electricity is the transmission of chemical or atomic action, and I speak of it as flowing, or being transmitted, in a definite direction.

Mr. PREECE:—For that reason I asked the question, because there is no difference as to the use of the term or the definition or

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value of the current; it is a pure convention. I do not think that we have any facts of any sort or kind to justify us in assuming that electricity flows in one direction rather than the other; but I would mention this, that in all recent inquiries that Crookes has made, and also Spottiswoode, before his death, they all had the tendency to show that if electricity does flow at all in any direction, that direction is rather from the lower to the higher potential, than, as we are all accustomed to admit and believe, from the higher potential to the lower potential. In other words, the tendency of the inquiry of Spottiswoode, De la Rue, and Crookes, and one or two German inquirers, whose names at present I forget, all rather tend to confirm your suspicion that electricity flows in the reverse direction to that which we are accustomed to admit.

Every other electrician present at the Exhibition, I think, has watched this experiment with very great interest. I feel puzzled in reference to it, and I feel that it is one of those things that wants to be very carefully and cautiously examined. It is also one upon which it is very dangerous to express an opinion. I was foolish enough the other night, when the experiment was shown to me at Mr. Edison's exhibit, to express an opinion, but I regret that I did so. However, I intend to exercise my persuasive eloquence upon Mr. Edison when I see him next week to induce him to give me one of those lamps, and when I go back to England I shall certainly make an illustration before our society there, and then make a careful inquiry into it. My own idea of electricity and the nature of this experiment is this: That for the production of the current you must have two things; you must have two points at different potentials, separated from each other by matter, and in this whether the direction be from the positive to the negative, or vice versa, is a matter of very little consequence; but to produce a current, as we have it here, we must have two points separated from each other by matter. The principal point here is what is that matter, and where is that matter.

I saw at Montreal an excessively beautiful experiment, tending to show that you had a Crookes' effect from platinum and carbon, just as much as we know that we have an effect from carbon and anything else. We know, for instance, in every incandescent lamp, that when you raise the filament to a certain condition of incandescence, there you have the Crookes' effect, because we see the carbon deposited upon the glass. But when we have platinum, it is a very difficult thing to prove that there exists the Crookes'

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effect. Dr. Oliver Lodge showed an extremely pretty experiment, to illustrate the fact that fogs resulted from the formation of moisture around a nucleus or molecule of matter. He took a large glass globe, apparently chemically clean, exhausted the air, but with moisture in it. It remained perfectly transparent as long as no matter was admitted, but the moment a spark from an induction coil was passed between the two platinum electrodes in this apparently chemically clean tube, at once a cloud was formed throughout the whole of the tube, showing that the passage of the spark between those two platinum points produces a Crookes' effect. That is, there was a bombardment of the platinum molecules, filling the whole of the tube, and the result was, the fog was formed. Now, here, suppose that that shall form, it may be, as has been suggested, that there is a new source of electricity. It may be it is due to something that we don't know of at the present. I am quite certain that we shall find the cause of this remarkable phenomena to be due to the Crookes' effect.

Prof. HOUSTON :—I would like to say, in answer to the gentleman who has just spoken, that I am aware of the experiments that he has mentioned, some of which have been urged as proving the existence of a negative current. It seems to me that all they show is the transference of matter from the negative to the positive pole. Now, whether that constitutes an electric current or not, I do not think we can quite determine. The peculiar thing about the experiments I have mentioned is in the reverse direction of the current when the galvanometer is connected to the negative terminal. The difficulty exists, however, in finding a satisfactory explanation of the phenomena observed ; whether the current is flowing from the positive or from the negative.

Mr. KEITH :—Mr. Chairman, I think the remark, or word, the convention, of assuming a direction for the current, may be used in electrolysis. The current may be considered as carrying metal from the anode to the cathode, and thereby producing a deflection of the galvanometer needle, or a positive-direction wave constantly to the right hand, or to the left hand, as indicated by the deflection of the needle. However, I have often noticed in arc lamps this fact: when we have a very long arc there oftentimes comes a sweeping movement around the ends of the positive and the negative carbon, and there is a little flame proceeding from the negative carbon towards the positive, which seems to rise, and have its point, or beginning, as we may say, upon the negative,

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running up like a brush towards the positive. You have current enough to spread around this surface, or portion of the surface of the upper carbon, seeming to emanate from the negative and proceeding to the positive. It probably has been noticed by everyone who has worked the arc lights, that same phenomena, as though something was passing from the negative and going to the positive. This cannot be quoted as an illustration of the transference of carbon from the positive to the negative, as is manifested upon the negative carbon when the short arc is used.

Mr. PREECE:—I think that some similar phenomena are noticed with the long platinum wire when it is raised to the state of incandescence. You find the heat commences at the negative end and flows in the other direction from some cause.

Mr. KELLY:—Some explanation ought to be given in reference to incandescent lamps at a high temperature. As to the current, I would say there is a discharge from one side of the carbon to the other. That is noticed to some extent in the same plate. Perhaps the induction is strong between the two sides of the carbon. Now, I don't see any special reason for supposing that when the platinum circuit is closed the discharge is interrupted; instead of passing from one carbon to the other, the discharge takes place between the negative side of the carbon and the platinum plate.

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A paper read by Mr W. M. Callender before the American Institute of Electrical Engineers, at Philadelphia, September, 1884; with discussion thereon.

UNDERGROUND WIRES.

The question of underground wires is now one of such universal interest, and one upon which opinions differing as widely as the poles are so freely expressed by those whom the public consider as its leaders, that I venture to think it may be of importance for this meeting to consider frankly what has already been done toward this end.

Underground wires may be roughly divided into three kinds—lighting, telegraph and telephone. That the placing underground of telegraph wires in cities presents no unsurmountable difficulty, either mechanical or electrical, is acknowledged by all electricians. It is only necessary to refer to what has already been done in Chicago and Washington to prove this practicability. The placing underground of telephone wires is also admitted to be practical, and no doubt many of you have recently had the pleasure of listening to Mr. Berthon, of the Paris Telephone Co., describing how successful has been his underground telephone system in Paris. Mr. Edison proves every day that wires for incandescent lighting can convey their current underground, and work, he claims, satisfactorily, and it is only when we come to the question of "arc" wires that any real difficulty has been experienced. That, however, it is possible to put arc leads underground, there is no room to doubt, and I purpose to point out to you, first, what are the special points necessary to insure a successful underground arc system, and second, where such a system is in practical use.

To place wires of any kind underground some sort of a conduit or receptacle is quite necessary, and while a tunnel or sub-way under every street strikes one at once as being *the* way out of the difficulty, still such a scheme must at once be discarded, in view of its cost, until such a time as the telephone and the electric light are in use in every household. Until that happy day the underground system, I think, will be somewhat piecemeal. Each telephone, each light and each telegraph company will no doubt try

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to work its own wires in its own way, to have its wires in its own conduit, allowing no rival to have access to them. Admitting

CABLE WITHOUT INSULATION.

CABLE WITH INSULATION.

this, let us see how this can be worked out. The problem before us is; suppose all the telegraph and telephone lines underground, how to place the electric light wires so that they will *work* and not incommode either their telephonic or telegraphic neighbors. A telegraph line is not injuriously affected by an arc circuit, even if in very close proximity, provided, as is always the case, there is a return wire for the arc circuits. A telephone wire is practically useless if in its neighbourhood there is an arc circuit, but if instead of using a single wire for your telephone, you use a metallic circuit, your instrument is in no way affected, and you get satisfactory results. These are, in a word, the conclusions arrived at after a long and thorough investigation into the subject of induction, made by the Gramme Committee last winter—and I think they are pretty generally accepted.

When arc lighting was first started here, overhead wires were of course adopted, and it is no doubt largely owing to their cheap construction, that arc lighting has made the wonderful strides it has in this country; and now that the public are clamoring for the removal of the unsightly poles which disfigure their streets, the companies are loath to sacrifice so much original expenditure, as in so many cases where they have tried an underground system

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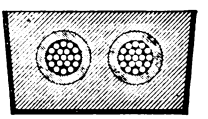
the result has been failure and loss, till now the feelings of the light companies toward the underground question is one of great caution and unbelief. I think all the companies are agreed that, if their wires can be placed underground, it is to their interest to have them there. Their scepticism is not to be wondered at, when we, as practical men, listen to the nostrums so frequently propounded by the many electrical quacks.

For underground work, the first thing to be decided upon is the conduit. There are many things which influence a decision as to its size and shape, but the following are absolutely necessary.

If it is under a street, it must be laid solidly, so that it cannot be shifted by the weight of the earth over it, and be strong enough to withstand the pressure and concussion of the traffic. It should be water-tight, and so arranged that the wires can be readily got at, when necessary, either for repairs, or when required to be tapped and a branch line taken from them, and above all it *must be cheap.* I have before me two sections such as have been successfully used in England, and these I will explain later on. The cheapest conduit which will naturally occur to you is an ordinary cast-iron pipe or a wooden trough, but both of these have their disadvantages. A cable for underground electric cable lighting is necessarily a costly thing, and the old maxim that insulated wire should be treated with respect, and as carefully as a new-born baby, is doubly true in respect to it. It is bad policy to haul any insulated wire through a pipe. It lays the cable open to damage and weakening at the hands of careless workmen, and this, where possible, should be avoided. In laying



END VIEW OF CABLES EMBEDDED IN BITUMEN, READY FOR LAYING IN ROAD.

a new line it is therefore advisable to have the top of the conduit removable, and to *lay* the cable in it, thus saving any chance of injury. A wooden box does not, in practice, answer so well as iron, and its economy, in England, at least, is *little.*

Having settled the question of conduit, the next question which arises is, what is the best conductor to use? The conductor must, of course, be of the purest copper, and it is to be preferred in the form of a strand, rather than as a solid wire. A stranded con-

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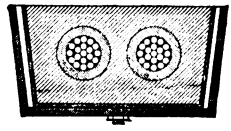
ductor need cost but a trifle more than a solid wire; it is more easily handled, and thus renders the cable less liable to damage. It presents a larger radiating surface, and is in every way preferable. The insulation of the conductor is of supreme importance, as upon its properties depends the success or failure of the circuit. When a high tension current is used with an E. M. F. of about two thousand volts, everything must be of perfect workmanship. A charge of this magnitude rushing through the wire tests and tries its capacity to the utmost. Any weak place in the insulation is soon found out, and a leak once started, the cable is doomed. The electricity will find its shorter way home, consum-



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ing everything in its course. It is, therefore, absolutely necessary that the insulation be such as will withstand a high tension current; that the workmanship be perfect; and, most important, that the insulation be protected from any danger of mechanical damage.

The only three insulating materials that need be considered are gutta percha, rubber and its compounds, and bitite or vulcanized bitumen—paraffine and the numerous cotton coverings, although very useful in their own place, are no good for underground, they will neither stand the dampness, nor in fact can they ever be considered as "insulating" a wire. For you cannot consider a wire insulated, unless when after soaking in a tank of water, and testing by means of a Thomson's galvanometer you get a high insulation resistance. A perfect underground wire should have the following qualities.

a. It should be permanent and unchanging.

b. It should have an affinity for the earth, and be unaffected by earth acids and changes of temperature.

c. It should be cheap, a good insulator and reliable.

The most famous of all insulators is certainly gutta percha, its tenacious gummy nature adapts it admirably for that purpose, and when under water and unexposed to the atmosphere it is recognized as the standard. The conductors of most submarine cables

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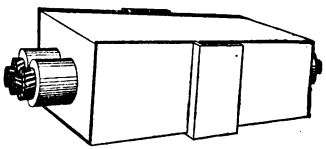
are insulated with gutta percha, and when electric lighting first became a fact, gutta percha was used in preference to all others.



CABLE AS LAID.

The objections to its use for underground purposes are, however, grave. While it is under water its life may be very great, but used in the dry it often rapidly deteriorates, the natural gum exudes and leaves only a brittle resin, which soon becomes useless. It is very susceptible to temperature, and cannot be handled with safety in a higher temperature than about 84° F., and thus, in this climate it is practically useless for underground electric light purposes.

Vulcanized India rubber (when pure virgin rubber is used) is also a good material, but it is always treacherous and uncertain even when best, and the temptation to use old and spent rubber, and to doctor it in its vulcanization, is always great—and soon tells. You cannot make a silk purse from a sow's ear, is a good old proverb. There are many different compounds of rubber, some better, some worse. After all, however, they are simply imitations of pure rubber and seldom equal it. Although both gutta percha and India rubber have long been good servants to electricians, and especially to telegraphists, it has long been felt that some new, cheaper and permanent insulator was wanted. Bitumen, as *the* most permanent substance known, has been a favorite field for chemists and experimentalists. Its chemical composition being so nearly allied to that of pure rubber, seemed to invite experiments, and I hardly know of any electrician of standing, in England at least, who has not in some way tried to make use of it as an insulator. Failure followed every attempt until Mr. W. O. Callender, of London, England, succeeded some years ago in producing this material "Bitite," or vulcanized bitumen, in which, by a peculiar secret treatment, he preserves all the lasting properties of bitumen, and adds to it many of the characteristics of rubber. A mineral insulating material is thus produced, which, having an earth as its basis, is perfectly suited for underground, while its low cost invites its use. Theoretically, it is *the* most perfect of

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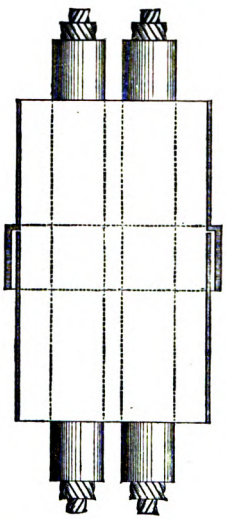
all underground insulations, and is accepted as such for all heavy work in England, and there in almost every important installation the main cables are insulated with the Callender Co.'s "Bitite." The House of Commons, Buckingham Palace, the New Law Courts, London, the estate of Lord Salisbury at Hatfield (where there are many miles of underground work) are among the best known installations in England, and in every case the "Bitite" wire in service is underground. It is used by the War Office, Admiralty, Indian Office and other departments of Her Majesty's Government, all the leading companies, Brush, Swan, Edison, Pilsen-Joel, Crompton, Maxim-Weston, Rogers, Fife Main and Jablochkoff, and in every case it is recognized as *the* wire for heavy underground work.

Naturally every street to be lighted presents special features to be treated specially, and if I describe several of the different systems already laid by the Callender Co., and the plans elaborated



PLAN OF CABLE-BOXES, SHOWING FRONT.

by them for the Edison-Swan Co., you will see their practicability and appreciate their simplicity and comparative economy.

In some cases where it has been found impossible to *lay* the cable, it has been necessary to draw it through a pipe. At Hatfield several of the cables were drawn through ordinary earthenware drain pipes, and in one installation for the Jablochkoff Co., where about twenty miles of cable were used, it was pulled through

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iron pipes, and I may mention to show what some people think of insulated wire that in this case it was drawn through by horses. How that wire did escape ruination has always been a subject of wonder. At Eastbourne, a town about fifty miles from London, lighted by the Brush Co., the wires are nearly all underground and work well. There the wires are drawn through an iron pipe, and a considerable part of them are insulated with "Bitite." In London itself there is not much permanent arc lighting, and there, where the system of pulling through pipes is not carried out, the following plan has been adopted:

An iron trough has been laid solidly, and coupled as shown in the sketch, and in this at intervals of about 18″ are placed bridges, made of insulite, a special preparation of bitumen, and on them the cable is laid. The bridges are inexpensive, and practical men will at once see their advantage in keeping the cables equally distant, and in facilitating their laying. When the cable is laid, pure melted bitumen is run in so as to cement cables, bridges and trough into a solid mass. Care is taken that the heat of the bitumen is not such as to injure the cables, but just sufficient to make a solid mass. The cables once laid upon this plan cannot go wrong, no injury can get at them, and you thus have a permanent piece of work. You may say that such a scheme is faulty, because it does not allow you to increase your number of cables without tearing up the street—although when the gas companies require larger mains, they are obliged to open up the streets. Still our difficulty may be overcome by laying such mains as are required at once, and allowing a free space over them in which the cables might be drawn in if necessary. The wires can be tapped and connection made easily in something like this way. The lid would be removed and the hard bitumen chipped off till the cable was exposed. A hole would be cut in the side of the conduit and to it would be screwed an ordinary gas pipe, making a water-tight joint, and through this pipe a branch house cable could be brought and joined in the ordinary way to the main cable; replace carefully the insulation and then pour in some more melted bitumen, and the deed is done—your connection is complete. Substantially, this is the scheme prepared under the instruction from the Edison Swan Co., and while its efficacy is certain, it scost is comparatively low. The main cables at the New Law Courts, London, and the cable for the Brush Co. (arc lights) at Plymouth, as well as many others, are on a modification of this plan. Granted the effi-

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ciency of this scheme, the question of cost is of next importance. Where there is only one wire to be laid, the cost is, of course, proportionately high. Where a larger number of leads can be laid, say eight wires (4 circuits) the cost of cable, conduit, bitumen and labor should be decreased to about twenty-five cents per foot per wire. These figures are, of course, only very rough, but are enough to give you an idea of the cost. It must be recognized that every piece of underground work is a special piece of engineering where special difficulties have to be overcome, and a scheme that is in all its details perfect for one place, may not be at all adapted for another, although the cost of each installation need not vary very much. That with such an underground system as I have described, the actual working expenses of a plant will be decreased goes without saying. The insulation will be more perfect; failures altogether done away with, no chance of interference owing to weather, and no breaking down of wires, are among a few of the advantages to be reaped from such a system. That the original cost of such a plant would be higher, is also true; but I maintain that true economy is not arrived at by the erection of the cheapest kind of work, but by the erection of some solid, permanent system, in which maintenance does not form one of the chief items, and such a system I have had the honor of laying before you to-day.

In conclusion, let me frankly state, that what I have advocated should be taken as "principles," not so much as "details." And these principles are—1. That to have an underground system for arc lighting, you must have a thoroughly insulated wire, and that such insulation must be able to withstand a high tension current without deterioration, and must be reasonably permanent; and 2. That the cable must be thoroughly protected from mechanical damage, must be easily got at, and must be easily tapped.

The scheme I have explained to you is the result of practical experience; it is not a fancy plan, simply evolved from out the imagination. It has withstood the test of two years' experience in England, and is to-day as perfect as when laid down, and it is acknowledged to be perfectly successful, and is admitted to be the cheapest scheme known, and, I am confident, will prove equally successful here.

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DISCUSSION.

THE CHAIRMAN (Mr. W. D. Sargent): Has any gentleman present any remarks to make on the subject of this paper? I would like very much to hear from Mr. Preece in regard to underground wires.

MR. PREECE: Is this a question of arc lighting by means of underground wires?

THE CHAIRMAN: Outside of that there are persons here who are interested in other underground wires, with which you are very familiar.

MR. PREECE: I have been striving very hard during the whole of my stay in this country to prevent being drawn into a discussion of this question of underground wires, and I am bound to confess that my first sensation on hearing the title of Mr. Callender's paper read was to take up my hat and walk, but that would have been an act of discourtesy to the members present, if I had done so; therefore I sat it out, and I have submitted to this very painful ordeal placed upon me by your President to say something on this much vexed question.

Now, it is not a vexed question in England. The question of aerial wires and underground wires is not a problem to be solved; it is a problem that has been solved; and whether a wire be put under ground, or whether it be put above ground, is simply a question of pounds, shillings and pence. As Mr. Callender has said, it is an engineering question, and if any town or village or any landlord wants a wire to be put under ground, he simply has to call in any ordinary English electrician, and he would not be competent to maintain the title of electrician unless he was able to give a clear, impartial and fair estimate of the conditions determined by putting the wire under ground. We know the cost, we know the durability, and we know exactly what to do in any case, whether it was arc lighting, incandescent lighting, telegraphic work or telephonic work. But I am far from saying that what governs us in England would govern you in the United States. I would not for a moment admit that the experience that we have had with underground wires in England is necessarily the same experience that you ought to have had. You ought to have done this years ago in the United States. But the conditions are totally different. You have a different climate, and you have different atmospheric conditions, and you work your telegraph in a very different way. You have a greater distance to go over, and

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you have both those extremes of heat and cold that we never get in our experience on the other side of the Atlantic Ocean. Hence our experience is not necessarily your experience. But with that experience on that side of the water, I don't think there is an engineer, however competent he may be for designing underground work in England, who is not equally competent to design underground work on this side of the water. Why it is you have delayed the solution of this question with you so long I cannot make out. When I was here, seven years ago, I saw your corporation spending heaps of money in beautifying your streets and in the erection of beautiful buildings, and then allowing them to be disfigured with those hideous posts overhead with wires strung on them. The only advantage that I have yet observed with those overhead wires has been that in hot weather in some place they form very convenient shade. Beyond that I know of no earthly reason why they should be put up. But while you have in this country gone to one extreme, that is in avoiding underground wire altogether, there is a strong tendency somehow to drive you to the other extreme, and that is to force you to put your wires underground. Now, I know the old story about leading the horse to the pond—you cannot make him drink, and I know quite enough of the American character to know that you cannot force telegraphic companies and telephone companies in this country to go under ground against their will. They must be led up to it gently. It is not ridiculous legislation, and it is not the passing of impractical and absurd measures that will force the wires under ground. It will be a gradual teaching of experience in reference to the working of the companies. I have come in contact, since I came here, with a good many telegraph people. I find they all say, and I am sure they are quite true in what they say, "Show us a practical underground system and we will adopt it." Well, I saw several experiments going on, and I can speak from experience of Mr. Callender's system. All he has said I think is to be recommended. In several instances we have given it a very fair trial on the other side of the Atlantic, and we have tried it faithfully and impartially, as we try every new system that is brought to us, solely on the question of pounds, shillings and pence. And from my own experience I can confirm all he has claimed for his material. We use it in pipes, and we also draw into those pipes copper wires coated with gutta-percha. We are perfectly satisfied with gutta-percha. We know exactly how much to allow for renewal.

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We know exactly the durability. All we want now is to have some substance that will give us the same advantages as the gutta-percha at a cheaper price. At the same time it is a question of pounds, shillings and pence. We know how much it costs us to maintain wires over ground. We know that if we have more than fifteen wires we go under ground, because it is cheaper. That has proved to be the case in England, and we put our wires under ground, because it is cheaper than to go over ground. But there is a serious disadvantage in underground wires, and one which would be felt here more than any other, and that is the retarding effect upon the working of the telegraph with the underground system when it is used. With the insertion of every mile of underground working we have a reduction of the rate of work. On such a circuit as between London and Glasgow it amounts to one word per minute, and in working from London to Glasgow at the rate of two hundred words per minute, if we had ten miles of underground the rate would have to be reduced to one hundred and ninety, so that we find on such a circuit that the insertion of this underground portion retards the rate of working.

Again with the telephone. I have heard many people say on this side of the Atlantic that you cannot work the telephone under ground. Well, that is simply an absolute mistake. You can work telephones under ground as well as you can work them over ground, but within limits. We have at Newcastle, in England, a very extensive telephone exchange with seven hundred subscribers. Newcastle is a town of over one hundred thousand inhabitants, and the whole of that system is worked with an underground system with no difficulty and no trouble of any sort or kind. But, again, there are limits. This question of static capacity that retards the rate of working all automatic circuits takes off the fine waves of sound that render articulation clear; and as you add mile upon mile of underground circuit, so your articulation diminished until at last you get to the point where articulation for telephonic purposes is practically difficult or impossible. The distance on wires that we use now, or the length of work, is twelve miles.

Within twelve miles you can work the telephone system on a metallic circuit as efficiently under ground as you can over ground.

Now, I say you have gone to the extreme. You have up to the present moment ignored underground working altogether. But

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there is danger of your been forced to the other extreme, of being forced under ground, although I do not think you will be so forced. I think the true solution will be as much as possible a matter of expense, as all telegraph companies and telephone companies will learn. They are perfectly willing to use an improved system of underground work. The people themselves would not admit of that destructive policy of cutting down the poles with axe and saw. I am told that in one town not a hundred miles away from Philadelphia, on the first of January, an armed body of men will turn out with axes and saws, and will cut down every telegraphic post in that city. I don't think it is at all likely that that will be done, for even the thought or idea is suicidal and foolish, and the public would not submit to it for one minute. Therefore on this question what I have to say is, judging from our experience in England, the underground working is as simple as A, B, C, and the more the question is examined, the more these new systems are tried, the more telephone companies will take a little more sense into their councils and try, so as to satisfy the public that they are trying a little underground working, and the telegraph companies the same, then the sooner will this question be settled, and the sooner will poor, unfortunate engineers like myself, who come over here, the sooner we shall be—I forget the exact words I want to use—the better pleased we shall be in the future to come over here with the hope that in running over for five or six months we shall escape from outside pressure and obtain needed rest. [Applause.]

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A paper read before the American Institute of Electrical Engineers, at Philadelphia, October, 1884; with discussion thereon.

SYNCHRONISM.

BY PROF. EDWIN J. HOUSTON.

Among the many practical problems whose solution has long been sought for, but sought for in vain, until very recently, is the problem of obtaining approximately absolute synchronism.

A pendulum completes its to-and-fro motion, or oscillation, in a given time, that is independent of the distance through which it swings, or, in other words, independent of the amptitude of its oscillation. The time required to make one complete oscillation being exactly the same as that required to make any subsequent oscillation. This fact is expressed when we say, that the oscillations of a pendulum are isochronous.

When we include the idea of any one event happening in exactly the same time as that required for another event to happen, we express this fact correctly by saying that the movements of the two are synchronous. That is to say, the two not only start together, but complete all parts of their motions in the same time.

In order to render the preceding clearer, let us suppose that two tuning forks be started in vibration. Either fork will continue to make isochronous vibrations, if the time required by such fork to complete any single vibration is the same as that required to complete any subsequent vibration. While the vibrations of either fork may be isochronous, it does not follow that the vibrations of the two forks are synchronous.

Either of the two forks may be isochronous in its motions, although one of the forks may make 256 vibrations per second, while the other makes 512 vibrations per second. Either of the forks is isochronous, because it requires the same interval of time to complete any single to-and-fro motion; but the two forks are not synochronous, since one of them makes 256 vibrations per second, while the other makes 512 vibrations. In order that they may be synchronous they must each make the same number of vibrations in the same time.

The modern idea of synochronism includes the additional notion that the two bodies must not only move through the same distance in the same time, but that also their motions during the

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entire time must be exactly similar, that is to say, that they must be synchronous at all points during their movements.

Let us suppose, for example, that two pendulums be started at exactly the same time and be permitted to swing for, say, one minute. It does not at all follow that because they make the same number of oscillations during that time that their oscillations have been necessarily synchronous throughout the entire time of their movements, that is throughout the entire minute; since, in accordance with the definition of synchronism we have above given, it is not only necessary that the two bodies shall have moved through an equal distance, or, in other words, shall have started and stopped at the same time, but that they shall have been synchronous in their movements throughout all parts of the entire number of vibrations made.

Many attempts have been made to attain synchronism, but up to within comparatively recent date, it would seem that these attempts have been unsuccessful in obtaining the synchronism to which reference have just been made; that is the synchronous movement, for an indefinite period of time, of free moving bodies mechanically independent. For example, a ratchet wheel and cog-wheel, controlled by pawls, star wheels, friction or other mechanical devices may be approximately synchronous in their movements, but with such movements I do not propose to treat, since they could not well be otherwise than approximately synchronous, and are not involved in a proper understanding of the term.

For example, the House Printing Telegraph, Hughes' Printing Telegraph, Calahan's Stock Printing Telegraph, Edison's Chemical Stock Printing Telegraph, Meyer's Multiplex Telegraph, Baudot's System of Telegraphy, Casselli's and Bonnelli's Autographic or Fac-Simile Telegraph, and Edison's Autographic Telegraph, are all operated by mechanically synchronized movements, which are brought into unison at given times by certain mechanical devices electrically controlled, which bring them to a full or partial stop by certain mechanical impediments, frictional or otherwise, to their free motion, and these corrections being in all cases prearranged, are made use of whether the movement of the machine requires them or not.

Such movements, however, are not comprised in the idea of synchronism as it has been above defined, nor are they worthy the designation of synchronous movements, since their move-

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ments are never free or independent of mechanical appliances. They merely afford instances where different apparatus are maintained in a somewhat approximate synchronism for a very brief interval, when they are stopped, brought into unison, and again started.

A considerable stride in the direction of true synchronism was made by Prof. Paul Le Cour, of Copenhagen, whose genius has created the phonic wheel, a contrivance by means of which a rapidly interrupted circuit in an electro-magnet keeps in even rotation an armature wheel, the impulses of the magnet being made effective by increments so fine on the armature wheel that a uniform movement, hardly attainable by any other known device, is produced.

In strong contrast with the previously mentioned efforts towards synchronism, we have to-day the practically perfect synchronism of Mr. Delany, who, with marvellous ingenuity, has succeeded in obtaining and maintaining synchronism in the highest and best sense of the term.

I will be better understood when I call your attention to the fact that he has succeeded in keeping two bodies, separated by hundreds of miles, in synchronous rotation for periods of upwards of seventy hours, without variation during that time of the $\frac{1}{1000}$ part of a second. This is equivalent to two entirely independent bodies, separated from each other by hundreds of miles, starting together and passing through a distance of nearly one hundred miles without varying the $\frac{1}{100}$ part of an inch in that entire distance, or the $\frac{1}{1000}$ part of a second during that entire time.

The period of seventy hours I have mentioned, has no significance, so far as the limit of time is concerned, since these movements can be maintained for weeks, or months, or even for an indefinite period, with a like degree of accuracy; it being only necessary to keep the Voltaic batteries, used in this system, in working order.

Mr. Delany has chosen for his system the phonic wheel of Le Cour as affording the movement the best suited for regulation by his synchronizing device.

I will pass over the results he has already obtained in the shape of multiplex telegraphy, which, as you are probably aware, has been in successful practical operation under his system for some months past. In this system, circuits, ranging in number from six to seventy-two, according to their capacity, have been obtained over

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a single wire, admitting of the transaction of from six to seventy-two separate messages, at practically the same time, either all in one direction, or any portion of the whole number in opposite directions. These circuits so obtained may be adapted to the Morse system or to the printing system, the Morse system being applicable up to twelve circuits at the ordinary rates of transmission; the speed of any number of circuits being dependent on the number of connections that any particular instrument gets with the line in a given time.

The operation of the Morse system by the Synchronous method involves a feature that has probably never been explained, and to it I will therefore call your particular attention. If we consider that for one complete rotation of the synchronized distributor, which constitutes one end of the line, the line passes over 72 contacts, which may be used for the transmission of messages, and, that under the sextuplex organization, each of the six operators' instruments would be connected to twelve of these contacts in the circle, and that the distributor rotates at the rate of $2\frac{5}{6}$ times per second, we will find that each of the six operators' instruments would be connected to the line 12 times for each complete rotation, or 34 times per second, and that all these operators have been put in connection with the line, and with their correspondents at the distant ends, through the synchronized distributor at that point, 34 times in a second. Now while one operator is making the shortest character or letter in the Morse alphabet, which is the letter *e*, consisting as it does of a single dot, let us see what takes place while this single dot is being transmitted. Let us imagine that when the first operator touches his key, and depresses it for the shortest interval of time that he is capable of holding it depressed, the distributor with its trailing finger, which is the end of the line, passes over one of the 12 segments connected to this operator's instrument, and transmits to the other end a portion of this single dot, but does not complete it until the other five operators have been placed in connection with the line, and the second, or third segment of the first operator's circuit has been touched by the trailing finger when the single dot representing the letter *e* is completed. Thus one dot is made up of two, three, or more shorter impulses, which manifest themselves on the polarized relay at the distant end, as one short signal, notwithstanding that portions of letters or characters have been transmitted by five other operators between the time of the beginning and the completion of this single

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dot. This is an irrefutable evidence of a synchronism that has never before been more than contemplated as but a remote possibility.

The operation of the printing instrument by this system is another illustration of the degree of perfection of Mr. Delany's synchronism, that is hardly less striking than the foregoing; since if seventy-two printing instruments are used, each instrument must be dependent on a single segment for its message, and an instrument at each end of the line being connected to a single segment correspondingly located; the distributor must connect the line with those single segments at precisely the same instant, otherwise no impulse for the indication of a letter on the type wheel will be received. Theoretically it might be supposed that the transmission of a signal, say from Philadelphia to New York, by an instrument connected to a single segment, would not necessarily require that the trailing finger in the New York instrument should be on the corresponding single segment at the time that the signal was sent into the line at the Philadelpia end. Or, that the trailing finger on the New York instrument might be one segment behind the segment corresponding to the segment on which the signal was sent into the line at Philadelphia, and that still that the signal could be received on the corresponding segment in the New York instrument, since the time required for that signal to pass and manifest itself in New York would be sufficient to allow the New York instrument to reach the segment corresponding to the one from which the signal was sent into the line from Philadelphia. The fact that it takes time for the transmission of signals according to the distance and other conditions not necessary to discuss here, no one will dispute it, but, that this time admits of variation of movement or departure from synchronism in Mr. Delany's machine, is disproved by the machines themselves, for, if another instrument be connected to the next adjoining single segment in each machine, and a signal be sent from *New York to Philadelphia* immediately after, or within about the $\frac{1}{500}$ part of a second afterward, the signal from New York is received in Philadelphia as perfectly as that from Philadelphia was received in New York, thus, showing conclusively that the conditions of variation before referred to cannot have existed, since otherwise no signals could be received from New York or Philadelphia, over the second segment, as the Philadelphia

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instruments would have left the segment before the signal could have been completed on the segment in the New York machine and transmitted to Philadelphia.

Probably the most extraordinary proof of practically absolute synchronism was demonstrated by the experiment recently made by Mr. Delany over the line between Boston and Providence, whereby a single dot was transmitted from Boston to Providence and automically repeated back and forth over the same wire at practically the same instant of time, travelling over different circuits in rotation backward and forward for the duration of five minutes, during which time it traveled four hundred and fifty thousand miles, this time, of course, being almost wholly represented by the movement of the armatures of the instruments. When we consider, however, the conditions involved in the transmission of a single dot, as in the case of the letter *e*, already referred to, the extent of perfection of the synchronism obtained will be understood.

Before concluding, I desire to call your attention to some contemplated applications of the wonderfully complete synchronism of Mr. Delany which he has conveyed to me. Among some of these may be mentioned fac-simile transmissions of the reproduction of signs, characters, or hieroglyphics. For instance, a fac-simile copy of a dispatch, a drawing of a map, or a pen portrait of an individual may be transmitted to any distant point. The prime condition necessary being synchronism; so that the time is probably not far distant when the civil authorities can render the identification of criminals almost certain by having their portraits in the hands of an officer on the arrival of the train upon which the criminal has fled. Or, a newspaper in these days of enterprising journalism, many have transmitted for publication a sketch of a great public disaster or of any other event calling for illustration.

In conclusion, permit me to say that the invention by Mr. Delany of practically complete synchronism would appear to go no little ways towards the solution of a problem that stares practical men so squarely in the face. I allude to the problem as to what shall be done with the electric conductors that are strung over the houses and through the streets of our large cities. Whether these wires are to be placed underground or are to continue overhead, is a problem which in my opinion, is as yet far from being solved. The increased capacity which Mr. Delany

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has obtained for every wire will, it is clear, greatly decrease the number of wires required for actual use and this makes the problem referred to somewhat easier of solution.

DISCUSSION.

Prof. HOUSTON :—I would say here, however, that Mr. Delany's system is not necessarily dependent upon the phonic wheel, as he has invented a magnetic motor which, when placed in connection with his automatic system of control, is capable of and containing exactly similar effects as are obtained with Lacour's phonic wheel.

Mr. Delany has very recently made an experiment on the telegraph line of the Pennsylvania Rail Road, and has sent messages from Philadelphia to New York and back again to Philadelphia. That was done last Sunday. I don't know how many relays were worked, but it worked successfully on the Pennsylvania lines.

In concluding this paper, I may mention, that I have had some conversation with Mr. Keith as to whether or not it would be advisable to go into a discussion of the means by which Mr. Delany has obtained his synchronism, and we came to the conclusion, that the time available to us is so short, that it would be worth while to go over the description of the means, which we can fairly suppose you are familiar with. Mr. Keith tells me, that when he publishes this paper, he will probably reprint some of the articles that I have written, which contain a full and exact description of the methods employed. Otherwise it would be difficult to compress any description of the system in the space of an hour. I see, very fortunately, that Mr. Delany is here himself, and if there is time, I would suggest, that he be called upon.

The CHAIRMAN (Mr. W. D. Sargent):—Mr. Houston has given us a very interesting paper. As I understand, Mr. Delany is here, and our time is limited—but we would be glad to hear from Mr. Delany.

Mr. DELANY :—I don't know as I have anything to say, unless some persons, not understanding the theory and principle of synchronism, would like to make inquiries, if so, I would be very glad to respond.

So far as an explanation of the system is concerned, I think it would be much more satisfactory, individually and collectively, if we would go to the exhibition and see the system in operation. There every facility is at hand to make a much clearer explanation

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as to how it is done, and that certainly would be much more satisfactory than anything I would attempt to do here. However, if any of the gentlemen have anything to inquire about, I would be very glad to enlighten them as far as I can. I take pleasure in extending to the gentlemen of the conference here a cordial invitation to come out and see our system in operation in the exhibition building. We will be there during the week, and when they come, if they will make themselves known, I shall take particular pains to show it to them.

The CHAIRMAN:—Your apparatus in that building is simply working in the building?

Mr. DELANY:—We have no outside facilities at all. On Sunday we worked from Philadelphia to Jersey City and back over the Pennsylvania wires with a No. 9 and a No. 8 wire. One was an old wire, I don't know its electrical condition, it seemed to be in pretty good order.

Mr. MAILLOUX:—You are working through an artificial resistance, are you not?

Mr. DELANY:—Yes, our battery is very limited, consequently we are restricted to a lower resistance. On Sunday we had the Pennsylvania Railroad batteries, so we were able to work through to New York and return.

Mr. KINTNER:—What is the longest circuit you have worked?

Mr. DELANY:—We worked a year ago over the American Rapid Line from Boston to New York. We had then only progressed as far as the quadruplex.

Mr. KINTNER:—Do you find any static trouble over that distance?

Mr. DELANY:—There we had static trouble, but they were overcome.

Mr. KINTNER:—By ground contacts?

MR. DELANY:—Ground contacts. This was entirely practical The ground contacts afforded us a mechanical remedy for getting rid of the static troubles within our reach. For a longer distance, it would only be necessary to make the ground contacts a little larger.

Mr. KINTNER;—I was thinking of that.

Mr. DELANY:—Or larger than the contact connected with the operators' instruments. Of course such an enlargement would to a certain extent be at the expense of the operator's contact. If we have ground contact about the same size, so the line will have

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the same duration with the ground that it had with the operator's instrument we can work very satisfactorily. The circuit referred to was 250 miles over a No. 8 galvanized iron wire. If it is necessary to work further over that kind of a wire we will probably have to put in repeaters or use a copper wire.

Mr. KINTNER:—Have you ever tried the condenser?

Mr. DELANY:—We could not use that very well, we could not apply the condenser, because our currents are constantly being reversed. We use polarized relays. So while it would assist in one instance, it would create a difficulty in the other.

Mr. KINTNER:—I had forgotten about the polarization.

Mr. DELANY:—We have worked successfully through three repeaters, and have worked through five; it was simply only necessary that the sounder of one circuit should become the transmitter in another circuit.

The CHAIRMAN:—To what extent is your system dependent upon the electrical condition of the conductor between the two ends?

Mr. DELANY:—We have but very little difficulty from that cause. Synchronism is maintained, if we get sufficient current over the line to actuate the armature of the correcting relay adjusted in the most sensitive way, the armature of the electromagnet is adjusted by a delicate spring, so as to keep the armature against the back stop. If we get a sufficient current over the line to move the armature from the back stop, we can synchronize. In fact we can synchronize further than we can telegraph. Any ordinary change in the condition of the line does not affect us at all, because frequently we have put three or four thousand ohms of resistance into the line, and taken it out suddenly without affecting our synchronizing apparatus. With polarized relays and reversed current a fluctuating condition of the line does not affect us as it would an ordinary relay. It is simply a question whether you get sufficient current over the line to actuate the most sensitively adjusted relay. As long as we can do that we can work.

Mr. MAYNARD:—Is it possible for these machines to get out of synchronism?

Mr. DELANY:—Oh, yes.

Mr. MAYNARD:—What do you do then?

Mr. DELANY:—They come in of themselves, if you let them alone within themselves two minutes. The correcting impulses sent over the line will correct a discrepancy in vibration of the

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forks of about five vibrations per second. If you should open a wire between the two stations, the instrument would then have to run independently, they would get out of synchronism within a minute or two. The instrument may be locked up and not be accessible to anybody. If they should be thrown out of synchronism they would come to that point again of themselves.

Mr. MAILLOUX:—Do you maintain the line of circuit so they can keep themselves in a synchronal condition.

Mr. DELANEY:—Oh, yes; the line of circuit is always closed, subject to interruptions, of course, of the commutator from the circuit table.

Mr. MAILLOUX:—I mean when the operator wishes to send a message in the ordinary way, he does not have to wait until the line is synchronized.

Mr. DELANY:—He has to wait until the line is synchronized to send the message; if he did not, the message would not reach the operators in connection with that circuit at the distant end.

Mr. MAILLOUX.—When the machine is in use on the line, I wish to inquire whether the machine is maintained in a synchronized condition?

Mr. DELANY:—It is always maintained in a synchronized condition. Each operator's instrument is always to the ground, so that if the operator at the other end of the line closes his key, it is manifested directly to the corresponding operator at the distant end.

Mr. MAILLOUX:—It is your purpose, is it not, to maintain that local circuit in action all the time, so that the phonic wheel is moving all the time at either end?

Mr. DELANY:—Always; at night we shut them down if there is no longer necessity for running them.

Mr. MAILLOUX:—You open in the morning and synchronize?

Mr. DELANY:—After we start them in the morning they run all day.

Mr. MAILLOUX:—With the ordinary Morse system how many transmissions can be made practically and profitably over one wire.

Mr. DELANY:—We make six transmissions by the Morse at the highest rate of the ability of the operator. That is, you can send forty words per minute — we have transmitted from Providence to Boston, and Boston to Providence and back to Boston by a line, which I suppose is a circuit of about 100 miles,

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very close to 1000 words on the sixth of a wire, *i. e.*, when the wire was distributed sextuplex at the rate of from 43 to 44 words per minute. I received myself over a twelfth of a wire on eleven hundred words at an average of twenty words and a fraction. It is equal to 18 or 20 words beyond a doubt. Now as to the commercial advantages of either the six or twelve divisions of the segments that is a question. For the commercial telegraphy I suppose that between two offices doing an ordinary telegraph business, the six circuits could be worked to the best advantage, because it requires the less number of operators to the circuit, and each circuit is equal to the best ability of the most expert operator. But for renting purposes, you may rent twelve circuits to a greater advantage than the six; beyond the twelve we have to abandon the Morse system and use Printers.

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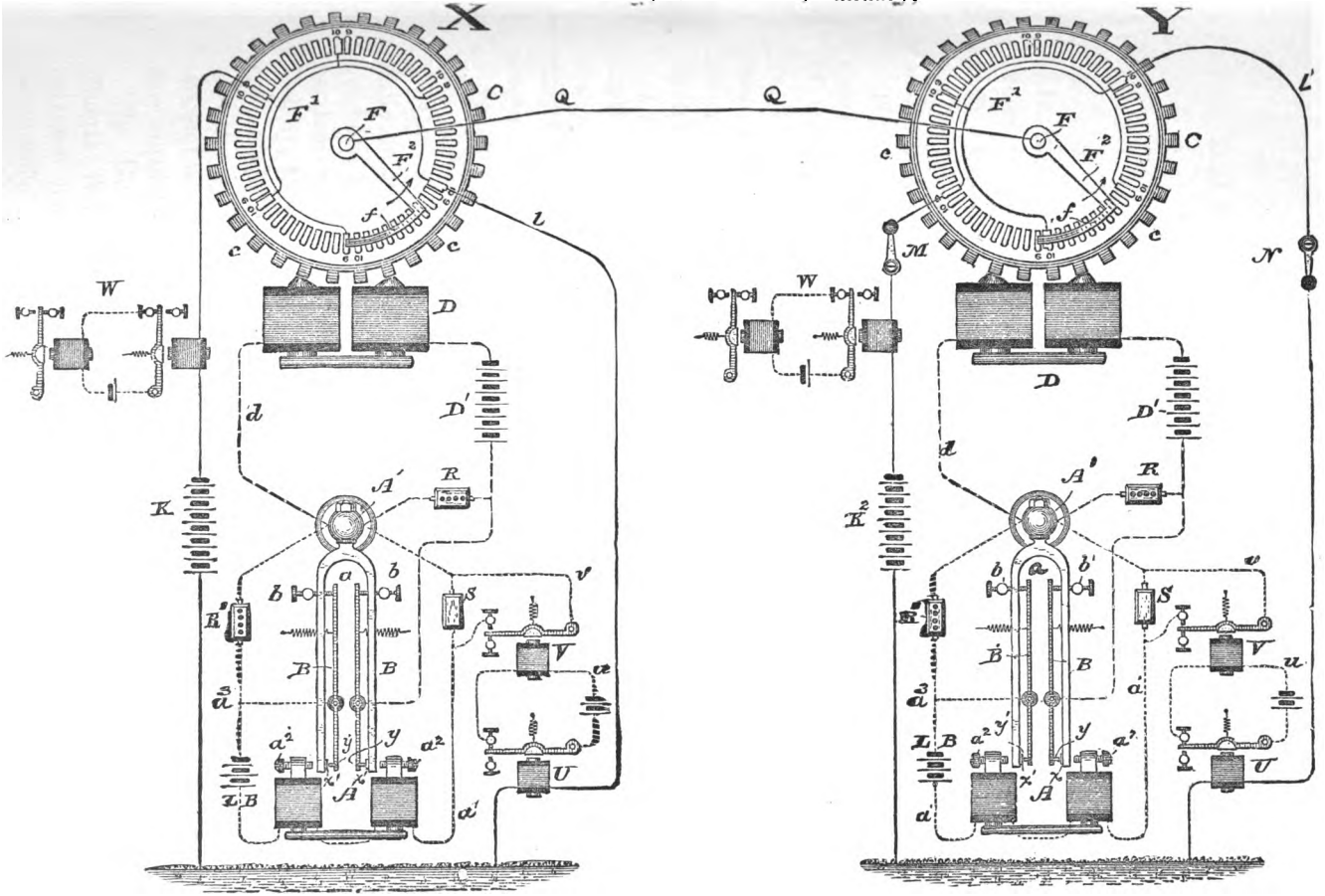

FIGURE 1.

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THE DELANY SYNCHRONOUS-MULTIPLEX SYSTEM OF TELEGRAPHY.

By Prof. Edwin J. Houston.

In this day of remarkable advance in electrical science, it is necessary for an invention to possess very unusual practical applications, and to display uncommon ingenuity or genius on the part of the inventor, to attract any more than transient attention or admiration on the part of the general public.

The successful laying of the Atlantic Cable, the commercial applications of electric illumination, and the actual transmission of telephonic dispatches, have very properly given to their inventors or promoters a world-wide reputation. The rapidity with which these inventions have followed one another, has led many to believe that but little new could reasonably be expected in the near future.

There has been, however, during the past two or three years, another inventor at work, who has at last completed, even to many minor details, an invention which, if we are not mistaken, bids fair to rival in importance anything that has hitherto been accomplished in electrical science; we refer to the system of synchronous-multiplex telegraphy, of Mr. Patrick B. Delany, of the city of New York.

Like other great inventions, that belong rather to eras than to individuals, the growth of the synchronous-multiplex system has not been entirely the product of any single mind; though, in this particular instance, too much credit can scarcely be given to Mr. Delany, to whom the practical or working part of the system is almost wholly due. Indeed, since this gentleman has introduced into the system the numerous details and separate inventions, without which its commercial application would be impossible, we may correctly speak of it as the Delany system.

The Delany synchronous-multiplex system is founded on the Phonic Wheel of Mr. Poul La Cour, of Copenhagen, who patented his invention in Great Britain, under Letters Patent, No. 1,983, of 1878; and in the United States, as No. 203,423, of May 7, 1878.

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Before proceeding to the description of the detailed apparatus of this remarkable invention, it will be best to first explain the nature of the work for which it is applicable, and to point out some of the more evident directions in which it may be practically employed.

The most evident commercial application of this system is its use for transmitting simultaneously, over a single wire, a great number of telegraphic dispatches, either in the same or in opposite directions.

Before the invention of the synchronous-multiplex system, the greatest number of messages that could be transmitted simultaneously over a single wire, as in the well-known quadruplex system, was four; and in this case, the four messages were, of necessity, sent in opposite directions; viz., two in one direction, and the remaining two in the opposite direction. In the synchronous-multiplex system, not only is the number of messages that can be transmitted greatly increased, but all such messages can be transmitted in one and the same direction; or any desired number sent in opposite directions. The great commercial importance of this feature of the invention will be at once recognized.

It may not be out of place to mention in this connection, as a confirmation of the importance of any system that will permit the simultaneous transmission of more than a single dispatch over the same wire, that it is a well-attested fact that the Western Union Telegraph Company has been enabled, to a very great extent, to practically control the telegraph business of the United States, by reason of its owning or controlling the only method heretofore known for successfully accomplishing this object.

Though we have mentioned the quadruplex as being the only system hitherto commercially employed for multiple transmission of dispatches, we have not forgotten the harmonic system of Mr. Gray. This, however, we believe, has not been commercially introduced to any considerable extent, owing to certain inherent difficulties attending its practical use.

Perhaps one of the most prominent features of the multiplex-synchronous system is its marked dissimilarity from either the quadruplex or the harmonic systems, already mentioned. The multiplex is a new departure in telegraphy, now practically realized for the first time.

As is well known to those acquainted with the principles of electro-magnetic telegraphy, the quadruplex system is based on

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the balancing or differential method, whereby the instrument of the transmitting operator, being unaffected by the signals he transmits, is thus left open for the reception of signals sent from the distant end of the line.

The synchronous-multiplex system, on the contrary, is based on the synchronous rotation of two discs, placed one at each end of the line, by means of which a single wire, which constitutes the line, is simultaneously connected, at both of its ends, to corresponding operating instruments, and transferred from one set of instruments to another so rapidly that the operators, either sending or receiving, cannot realize that the line has been disconnected from their instruments and given to others, because each of them will always have the line ready for use, even at the highest rate of manipulation, and will, therefore, to all practical intents and purposes, have at his disposal a private wire between himself and the operator with whom he is in communication.

It will be seen, therefore, that in the synchronous-multiplex system, although more than one operator may be spoken of as simultaneously using the line at any given time, yet, in point of fact, no two operators are in reality absolutely using it at the same time; but that they follow one another at such short intervals, and the line is taken from one operator and transferred to another so rapidly, that none of them can at any time tell but that he has the line alone, and that therefore it is practically open for the use of every operator just as if he alone had control of it.

There will be practically established, by the use of a single line, as many private and separate lines as there are transferences of the line from the time it is taken from the first operator, and again given back to him.

This has, as we will hereafter point out, been extended in actual practice to as many as seventy-two distinct and separate circuits, maintained and operated on a single connecting wire.

It will be readily understood that the rapidity of transmission of each telegraphic dispatch will be necessarily diminished as the number of messages that are simultaneously transmitted is increased. This decrease in the rate of transmission, however, is far less than might be supposed necessary, as actual experience has abundantly demonstrated. For example, with the simultaneous use of six Morse telegraphic circuits, the most rapid rate of transmission attainable by the most expert operators is practicable; and with twelve Morse circuits, a rate of transmission is

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practicable as rapid as that generally employed by the ordinary operator; that is, by an operator whose rate of sending would be regarded as equal to that actually employed by the greatest number. It must not be supposed, however, that the use of the multiplex-synchronous system will be limited to the simultaneous transmission of twelve separate messages on one and the same wire, since certain contemplated improvements will, it is confidently believed, greatly increase both the rate of transmission and the extent of division of the line.

There have been actually applied to a single line, as we have already mentioned, as many as seventy-two separate and independent circuits. In this case, the Morse instruments have been replaced by the ordinary printing telegraphic instruments, so that the messages are received and recorded on paper slips, in the well-known manner as practiced in the stock printing instruments.

Although the rate of transmission is, in the above case, considerably decreased, yet the adoption of a printing instrument is attended with many advantages that go far towards removing the slight inconveniences that result in actual commercial use. A printing instrument, as is well known, requires no special skill on the part of the one who operates it. Any one who can spell can transmit a telegraphic dispatch, while no operator need be on hand for its reception, since the receiving instrument is entirely under the control of the person sending the dispatch. The necessity for skilled operators at each end of the line is, therefore, in a manner entirely done away with.

Three very considerable advantages are obtained by employing printing instruments, and thus doing away with the services of skilled operators for sending and receiving the dispatches, viz.: economy, secrecy, and an increase in the number of messages that can be sent during any given time.

The advantages on the score of economy and secrecy are manifest. Not only is the skill of an operator required at each end of a private line employing Morse instruments, but, since private messages are to be transmitted thereon, integrity, as well as skill, is a prime essential, and both of these requisites must be paid for. On private lines, maintained by the use of the synchronous-multiplex system and printing instruments, no publicity is necessary, the interested parties only, sending and receiving the dispatches.

The advantages on the score of rapidity, arising from no operator being needed at the receiving station, when printing instru-

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ments are employed on a private line, lie in the fact that the line being a private one, no time is lost in waiting for some other party that may be using it, nor in calling the party for whom the dispatch is designed, or in waiting for his return, during a temporary absence.

Taking all these facts into consideration, we think it will be found in actual practice, that the decrease in the rapidity of transmission, consequent on the simultaneous employment of seventy-two separate circuits on one and the same line, is not sufficiently great to interfere, to any marked degree, with its commercial applications. In point of fact, with the system as it is now actually used, the rate of transmission is quite sufficient to enable each of the seventy-two subscribers or users of the line to transmit, during, say, the six hours that elapse between 10 A. M. and 4 P. M., the business hours of the day, no less than one hundred telegraphic dispatches of the ordinary length, an amount generally in excess of actual requirements of ordinary business, and, as a rule, quite in excess of any rate of service that could be reasonably expected on the part of any of the telegraphic companies on which the general public are now dependent.

An advantage, however, of peculiar importance to the business public generally, that is possessed by the synchronous-multiplex system alone, is the readiness with which a single wire between any two subscribers connected therewith can be increased in its capacity to meet the growing needs for an increased extent of division, or to meet some unforeseen or unexpected emergency. Thus, suppose that one subscriber has a private line placed at his disposal between any two distant cities, and is furnished with what we may term one seventy-second of the line; should his business increase, it would be a matter of simple connection of the transmitting and receiving instruments at the ends of the line to give him increased facilities for communication by placing at his disposal the one thirty-sixth, or the one-eighteenth, and so increase his capacity for communication twice or four times, respectively. In other systems, as is well known, this would need the erection of extra lines, and would necessitate the expenditure of both time and money, so that sudden and unexpected calls for increased facilities for business, which are liable to occur in times of financial crises, or of other great public excitement, could not be met.

A peculiar feature of the synchronous-multiplex system, that is

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not possessed by any other known telegraphic system, and that cannot fail to commend this system to the general public, is in its absolute secrecy. Unlike other systems, its lines cannot be secretly tapped and the messages intercepted, since an ordinary instrument placed in a break in the line would receive, in an utterly unintelligible form, not only all the signals being transmitted at the time, but also each of the separate makes and breaks in the continuity of the line circuit, while it is successively transferred from one operator to another, and these signals would be so transposed and altered, that even if the instrument could record them, they would be as devoid of intelligent connection as would the type correctly set for numerous messages, and afterwards dropped through successive sieves from a height to the ground. This feature of absolute secrecy of the synchronous-multiplex system will, it is believed, prove of almost inestimable advantage to a government for the secret transmission of dispatches during war, or, in fact, at any time.

The successful operation of the synchronous-multiplex system is dependent on the maintenance of the synchronous movements of the rotating discs placed at the ends of the line. We will now proceed to describe the details of the very ingenious and beautiful contrivances whereby Mr. Delany has practically created a new system of telegraphy.

Fig. 1 represents a diagrammatic plan of two distant stations, say, New York and Philadelphia, or Philadelphia and Chicago, represented by X and Y, respectively, electrically connected by the single line wire Q Q. The connections of the detailed apparatus required at both the transmitting and receiving stations are also shown in the figure.

In the following description the author has not hesitated to freely employ the language of the various patent specifications in all cases where he has deemed it advisable so to do.

An inspection of Fig. 1 will show that the apparatus at each end of the line, at the stations X and Y, is substantially identical. A steel fork a, at each station, is automatically and continuously vibrated by the action of the local battery L B and the electro-magnet A. The circuit of the local battery is marked in the drawing a^1. The cores of the magnet A, which may be called the vibrator magnet, are prolonged in the direction of the free ends of the vibrating fork by the regulable screws a^2, of magnetic material, in the manner shown in the figure. The object of this

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adjustment of the extended magnet poles is to enable the said poles to be approached towards, or withdrawn from, the tines of the vibrating fork, so as to regulate with great nicety the rate of their vibration.

Platinum contacts x x^1, are placed on the inner faces of the tines of the fork, and make and break contact with delicate platinum contact springs y, y^1 supported by adjustable insulated arms or levers B, B^1, pivoted on the bed-plate of the apparatus. The adjustment of these levers is secured by the thumb screws b, b^1, against which they are drawn by the action of spiral springs. By these means the platinum contact-springs, y y^1, are readily adjusted with great delicacy and firmness to the platinum contacts x, x^1 on the tines of the fork.

The circuit of the local battery L B, which is indicated in the drawing by the fine dotted lines, runs from the positive pole of the battery, through the coils of the vibrator magnet A, to the head of the fork, and through the contacts x^1, y^1 to the insulated lever B^1, from whence it passes back to the opposite pole of the battery. In order to prevent injurious sparking of the contacts x^1 and y^1, a resistance coil R^1 is placed in a shunt circuit around them, extending from the point a^3 to the head of the fork, and to the insulated arm B^1, as shown.

The fork being mechanically started into a vibratory motion, will automatically make and break its local circuit, and thus send impulses into the fork-magnet A that will continuously maintain the vibrations of the fork, in a well-known manner.

These movements, it will be observed, have been maintained solely by the making and breaking of the contacts x^1 and y^1.

And now for the contacts x and y, which, as we have seen, are placed in connection with the opposite tine of the fork. The making and breaking of these contacts, consequent on the fork's vibration, opens and closes the circuit of another local battery, in which is placed an electro-magnet D, the function of which is to maintain the continuous rotation of the transmission apparatus C.

This circuit, which we will call the motor circuit, and which is indicated in the drawing by the larger dotted lines, passes from the positive pole of the motor battery D^1 to the lever B, through the platinum contacts y and x, to the tine of the fork, to its head or support A^1, and thence through the wire d to the coils of the motor magnet D, and back to the opposite pole of

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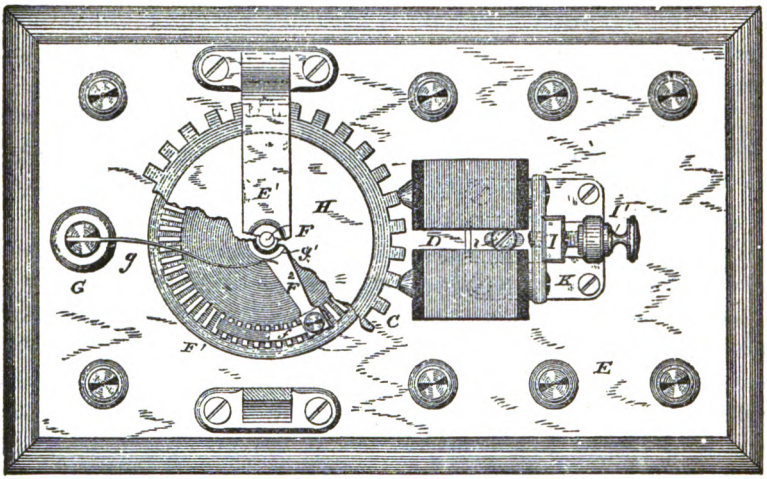
the battery. A resistance R, placed in a shunt between the head or support of the fork and the line of the lever B, prevents injurious sparking between the platinum contacts x and y.

As the continuous vibration of the fork is automatically maintained by the local battery L B, as already explained, it will, at each vibration, make and break the contacts at x and y, and thereby make and break the motor circuit. The alternate magnetization and demagnetization of the cores of the motor magnet D causes the rotation of the transmission apparatus C. The cores of the magnet D have their faces shaped so as to conform to the circumference of the apparatus C, the teeth of which pass in close proximity to the faces of the curved magnet poles.

The motor magnet and transmission wheel, or disc, C, provided with projections c, c, is the invention of Poul La Cour, already referred to, and is styled by him "phonic wheel."

The transmission apparatus is illustrated in detail in Figs. 2 and 3. As we have already seen, it is an exact counterpart of

FIG. 2.



the receiving apparatus at the other end of the line. A base plate E, provided with binding posts for electrical connections, carries a vertical rotary shaft F, that has its lower bearing in the bed-plate, and its upper bearing in a suitably supported bridge E^1. A circular table F^1, provided with a series of insulated contacts, is arranged symmetrically around the axis of rotation of the shaft. A radial arm F^2 projects from the shaft F, and

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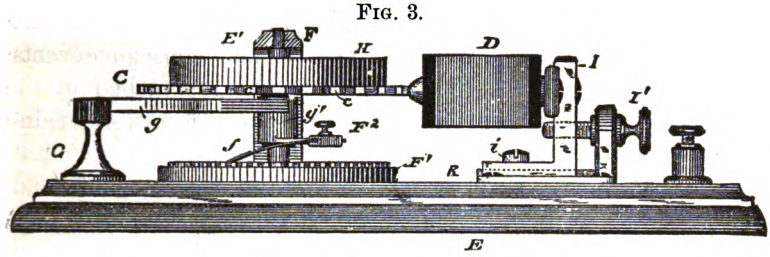
FIG. 3.



carries at its outer extremity a socket and set screw, to which is attached a trailing contact finger *f*. As the disc *C* is rotated by the electro-magnet *D*, the trailing contact *f* sweeps around the circular table F^1, and is brought successively into contact with the insulated contact pieces placed on the upper face of the table F^1.

The main line *Q Q* has one of its ends connected with the trailing finger *f*, through the radial arm F^2, vertical shaft *F*, contact spring-arm *g*, and projecting post *G*. As the shaft *F* rotates, the line is, therefore, brought into successive electrical connection with the series of insulated contacts in the upper face of the table F^1. The toothed armature, or phonic wheel, *C* is securely keyed to the vertical shaft, *F* just above the hub g^1.

In order to equalize the speed of rotation of the apparatus, a cylindrical vase *H*, of wood, or other suitable material, filled with mercury, is attached to the face of the phonic wheel *C*, and rotates with it.

The cores of the motor magnet *D*, suitably supported by the standard *I*, can be readily adjusted towards, or from, the armature teeth on the phonic wheel *C*, by the motion of a screw I^1, which moves the standard *I* in an elongated guide slot, through which passes the screw bolt *i*.

The cause of the synchronous rotation of the phonic wheel *C* is substantially as follows, viz.: Considering the action of a single pole of *D* when the wheel *C* is at rest, that one of its teeth, or projections, *c* that is nearest the pole of *D* will be attracted towards it, and maintained in position nearest it, by the influence of the magnetic attraction of the pole of *D*; should, however, the phonic wheel be set into motion, with a velocity that shall cause a tooth *c* to pass the pole *D* for each intermittent impulse in the battery circuit traversing the coils of *D*, the wheel will be maintained in a rotation, the speed of which will be regulated and controlled by the frequency of intermissions of the

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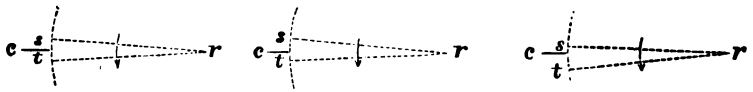
battery current through the coils of D. That is to say, the speed of rotation of the phonic wheel C, and consequently the rapidity with which the successive contacts are reached by the trailing arm F^1, are regulated solely by the duration of the oscillation of the fork a.

FIG. 4. FIG. 5. FIG. 6.



The control which the intermission in the circuit traversing the coils of the electro-magnet D exercises on the regularity of rotation of the phonic wheel C, will be better understood from an inspection of Figs. 4, 5, and 6.

Suppose that the central or axial line of the pole of the magnet c is represented by the dash placed opposite c in the figure, and that r indicates the centre of the phonic wheel C, whose direction of rotation is indicated by the arrow. Now, if during one impulse, the central or axial line of one of the magnet teeth c on the phonic wheel is moved from the point s to t, it will be accelerated on its way from s to c, but retarded from c to t.

If, then, as shown in Fig. 4, the acceleration and retardation are equal, the velocity of the wheel is unaffected by the impetus of the electro-magnet; but, should the wheel move slower, that is, lose in its motion, as shown in Fig. 5, then the acceleration s, c will increase, and the retardation c, t will decrease. Consequently, the electro-magnet D will increase the velocity of the wheel in the same ratio that the wheel slows, or loses time.

If, however, the wheel gains or increases in speed, as shown in Fig. 6, the acceleration s, c will be decreased, and the retardation c, t increased, so that the electro-magnet will have the opposite effect, and retard the wheel, in the same ratio that it tends to increase or go faster.

In the apparatus for transmission and reception, shown in connection with Fig. 1, which is substantially the same as that just described, the table of contacts F^1 is, for convenience of illustration, shown as placed above the armature disc C. In starting the disc C, an impulse of rotation is given to it somewhat in excess of the speed at which it will be maintained by the motor magnet, when, as the speed of rotation decreases, the armature teeth will come into proper relation with the poles of the magnet,

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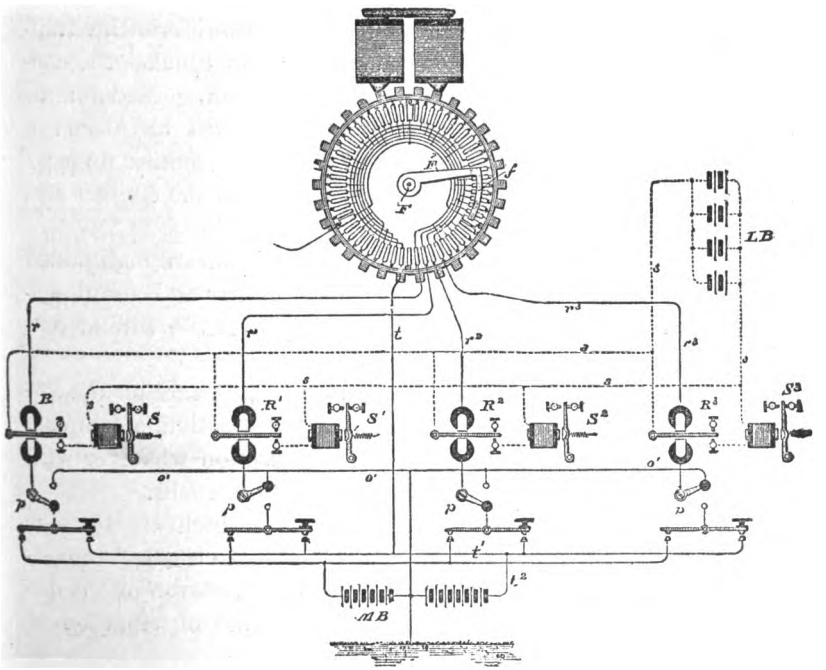
and into the periods at which the makes and breaks occur in the circuit traversing its coils, when the disc will be continuously driven by the motor magnet. A suitable thumb-piece, placed on the vertical axis F^1, serves to start the apparatus, an operation that is readily accomplished after very little practice.

Any suitable number of insulated contacts may be placed on the circular table F^1; sixty are shown in the figure. In practice these contacts are connected in accordance with the special number of circuits which it is desired to simultaneously maintain on the same wire. In the special case shown in connection with Fig. 7, it is arranged so that four separate circuits shall be established on the same line wire. The sixty contacts are placed in six independent series, numbered from 1 to 10, consecutively. In the arrangement here shown, two of the contact pieces in each series of ten are connected in the same circuit, and as there are six series, each of the circuits so connected will have twelve contacts for each rotation of the disc. An inspection of Fig. 7 will show that the 1's and the 5's in each series are all connected in one and the same circuit; the 2's and the 6's in another circuit; the 3's and the 7's in another circuit; and the 4's and the 8's in another

FIG. 7.



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circuit—thus providing four separate circuits, in all. The contacts, therefore, from one to eight in each series, are apportioned among the four independent circuits, each of which will receive, for each revolution of the trailing finger, twelve contacts and twelve electrical impulses, as will be afterwards described.

The detailed mechanism, by means of which the separate and independent circuits so obtained are utilized for the transmission and reception of messages, is shown in connection with Fig. 7. R, R^1, R^2, and R^3 are polarized relays, the function of which will be afterwards explained. S, S^1, S^2, and S^3 are ordinary Morse sounders, although in the practice of this invention some improvement has been introduced in connection with the instrument. The connections with the main and local batteries M B and L B are clearly shown in the figure.

It will be noticed that the relay R is connected by the wire r with the contacts 1 and 5; R^1 is connected by r^1 with the contacts 2 and 6; R^2 by the wire r^2 with the contacts 3 and 7; and R^3 by the wire r^3 with the contacts 4 and 8. Similar instruments and circuits are placed at each end of the line.

Without further describing the operation of the instruments shown in Fig. 7, it need only now be borne in mind that the corresponding relays at the distant stations are connected with the correspondingly numbered contacts. When, therefore, the trailing contact finger at each station simultaneously touches the contacts bearing the same number, the corresponding instruments connected with these contacts at each station will be placed in communication over the main line, the trailing contact finger f completing the connection of the main line with the contact arm in the manner already described.

If, then, the trailing fingers f at each station are maintained in synchronous rotation, they will pass regularly and simultaneously to the next contact, and successively over the similar contacts at each station.

During the time that the trailing contact fingers are on the correspondingly numbered contact pieces at each station, a complete and independent circuit, that has no connection whatever with the other circuits, is established between these stations.

Under the arrangement shown in Fig. 7, each of the four separate circuits will be placed in independent electrical connection with the main line, twelve times for each rotation of the distributing wheel C. Assuming the normal rate of vibration of

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the fork at eighty-five vibrations per second, and that the distributing wheel C is furnished with thirty armature teeth, or polar projections, the armature discs and trailing fingers will be rotated at the rate of two and five-sixths times per second, so that the corresponding instruments at the two stations will be placed in independent electrical communication with the main line, thirty-four times each second. This number of contacts per second will give to each set of operators a practically unbroken circuit, so that the operators at any two connected stations may communicate with each other, in either direction, as if they had a separate and independent line devoted entirely to their exclusive use.

We will now describe, in greater detail, the method adopted for transmitting and receiving the messages over any, or all, of the four circuits so provided. An inspection of Fig. 7 shows the relays R, R^1, R^2, and R^3 connected with the series of contacts, as described, and the circuit completed from each relay, either to the ground through the line o^1, when the switches p are placed as at R^1 and R^3, on their upper contacts, when the line is ready for receiving; or in connection with their lower contacts, as at R and R^2, when the line is ready for transmitting.

The main battery $M\ B$, preferably split and grounded in the middle, has its positive pole connected with the back stops of the keys, and its negative pole with their front stops. The action of transmitting, therefore, sends into the line impulses of opposite polarity, and therefore permits the employment of the polarized relays. The local battery $L\ B$ is connected in multiple arc, in the manner clearly shown in the drawing.

Since each operator's circuit is made up of numerous rapid contacts with the main line, at the rate of thirty-four contacts per second, each of the ordinary Morse characters sent into the main line is made up of more than a single contact, proportioned in number to the length of the character, the ordinary Morse relay could not be employed for the reception of these characters, since the numerous breaks comprised in each character would be recorded by the armature of the relay. In order to avoid this confusion, and to make the relays respond not to mere pulsations caused by the successive makes and breaks, but only to the reversals in polarity, caused by the connection of the split battery $M\ B$ with the transmitting keys, the polarized relays R, R^1, R^2, and R^3 have been used in place of ordinary relays, so that

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the armatures of the polarized relays remain in the position that the last current has placed them, until reversal of the current changes their position, notwithstanding that the finer vibrations comprised in these reversals are continuously passing through the magnet of the polarized relay, but are not manifested on the armature. This feature of the invention is due to Mr. E. A. Calahan, the inventor of the gold and stock printing telegraph, and also the inventor of the American District Telegraph System, and who has been associated with Mr. Delany from the commencement of his investigations on the subject, and whose ability and great mechanical skill have very materially aided the full development of the system.

The prime essential for the successful application of the preceding system is undoubtedly the maintenance of the synchronous movements of the trailing arms over the contact pieces on the table F^1. This Mr. Delany has effected by an invention of marvelous beauty and ingenuity, which is entirely automatic in its operation, and is so successful in practice that the synchronism can be perfectly maintained for days continuously without one instrument varying from the other the six-hundredth part of a second during that time. We will now proceed to an explanation of the comparatively simple means by which this practically absolute synchronism is maintained.

It has been shown, in connection with the description of the operation of the transmitting wheel, that its rate of motion is absolutely controlled by the rate of vibration of the fork, by means of which the successive impulses of the battery current through the motor magnet are regulated.

Now, it has been tried, but unsuccessfully, to obtain this synchronism by the mere mechanical adjustments of two forks, one at each end of the line; the forks being delicately tuned to exact unison with one another.

The many circumstances which produce slight variations in the rate of vibrations of a fork, have rendered it impossible to maintain, even in the same room, synchronism between two forks for more than a few minutes at a time, and this has only been possible by the most careful attention to the adjustment of the same. At distant stations, where the mere differences of temperature alone would, of necessity, produce sensible variations in the rates of motion of the two forks, the maintenance of even approximate synchronism would be practically impossible.

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Mr. Delany has completely overcome this hitherto insuperable obstacle to the successful adoption of any synchronous-multiplex system, by the happy invention of correcting impulses, that are automatically sent over the main line from one instrument to another, at such times only as the distant instrument is slightly in advance or behind the other instrument. These correcting impulses, that are thrown into the line only when needed, and of the necessity for which the instruments themselves, so to speak, are constituted the judges, are utilized for the purpose of slightly increasing or decreasing the rate of vibration of the distant fork, and, consequently, the rate of rotation for the trailing arm at the distant station.

The manner in which these impulses are obtained when needed is as follows: It was probably remarked by the reader, that in speaking of the contacts in the plate F^1, no mention was made of the 9's and the 10's in any of the series, as having connection with any of the telegraphic instruments or circuits. It is the function of these contacts to maintain the synchronism of the apparatus.

Referring again to Fig. 1, it will be noticed that at one of the stations, as X, three of the 9's, that are the furthest removed from one another, that is, three that are 120° distant from each other, are connected together, and to a battery K, one pole of which is connected to the ground; and that three of the 10's, that are likewise furthest removed from one another, are connected together and to a line l, leading to the correcting and regulating devices, which we will afterwards describe. The remaining three intermediate 9's and 10's are left open, that is, are not connected with any circuit.

At the other station, Y, the 9's, corresponding with those connected with the battery at X, are left unconnected, or open, while the alternate 9's are connected with the battery K^2, one end of which is grounded, while the 10's, at Y, which are connected with one another, and with the connecting devices through the line l^1, correspond with those which are unconnected with the station X, the remaining 10's, at Y, being unconnected at both stations; the three 10's, which are connected with the correcting devices through the lines l and l^1, respectively, are extended or built out towards the adjoining 9's, that are unconnected with any circuit.

In order to provide room on the table F^1 for the expanded

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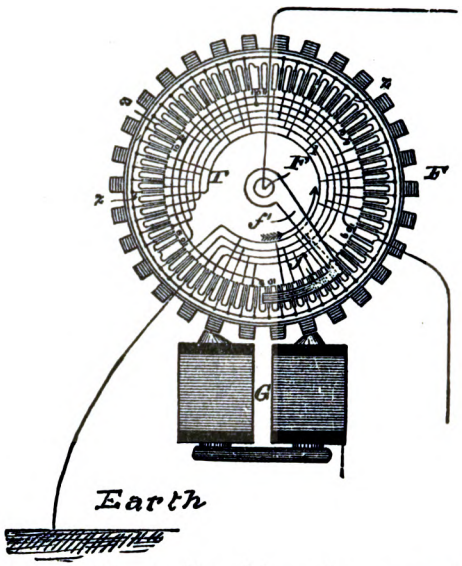
FIG. 8.



or extended 10's, without disturbing the symmetrical arrangement of the remaining contacts, the plates or contacts provided for the static discharge of the line, and which an inspection of Fig. 8 will show, as located between each of the successive contacts of the circular table F^1, are omitted, and their place occupied by the extension of the expanded 10's, so that the space between the expanded 10's and the 9's which precede them is the same as the spaces between the remaining contacts. Since the 9's preceding the extended 10's, and corresponding in position to the battery-connected 9's, are open or disconnected, and since the static discharge plate between the 9's and the 10's at the distant end is retained, no bad results are experienced.

As long as the trailing contact fingers are moving synchronously at both stations, that is, as long as they rest on correspondingly numbered contacts at the same moment, no occasion will exist for the correction of either apparatus; should, however, the instrument at Y run a trifle faster than that at X, the trailing finger f, at station Y, will touch the extended side of a 10 contact, while the finger at X is still on a battery-connected 9. An electrical impulse, consequently, will flow from the battery K, at station X, over the main line, and through the contact 10, at Y, and the line, l^1, to the connecting device at that station.

A similar operation occurs if the apparatus at X moves a trifle faster than that at Y.

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As thus arranged, the correcting impulses are retarding ones, since they are called into action only when the instrument at one or the other end of the line gains in speed slightly on the other. The inventor causes them to act as retarding impulses by employing them to cut a resistance out of the circuit of the vibrator battery. The effect of this is to increase the strength of the current traversing the coils of the electro-magnet *A*, and consequently its magnetic attraction for the tines of the fork. There thus results an increased amplitude of the fork's vibration, and a consequent lowering, or decrease, in the rapidity of its vibration. This retardation will, of course, affect the speed with which the transmission wheel is rotated, and consequently retard the rotation of the trailing finger.

The local circuit of the vibrator is shown in Fig. 1 as working generally through the adjustable resistances *S*. When, however, the apparatus at one station runs slightly in advance of that at the other station, and a correcting impulse is consequently received through the main line and the line *l*, or l^1, the relay *U*, placed in that line, is energized, and its armature drawn from its back stop, thus breaking the local circuit *u*, and permitting the armature of a second electro-magnet *V* to rapidly pass to its back stop, and thus complete a shunt circuit *v* around the resistance *S*, so as to cut it out of the vibrator circuit. The consequent increase in the current strength of the vibrator circuit that is thus momentarily produced, retards the rate of vibration of the fork, and consequently slows the rotation of the trailing finger, and causes it to drop back on its proper contact. The operation is the same at both stations.

Whenever the operator at either station hears the stroke of the relay *V*, he knows that a correcting impulse has been received. By placing a relay and sounder *W* in the circuit of the correcting battery, at each station, between the 9 contacts and the ground, he can also tell when a correcting impulse has been sent out. No difficulty will be experienced, therefore, in ascertaining which of the instruments is slightly in advance of the other, but as long as any ticks or sounds are heard on the instruments on the correcting circuits, the instruments will be found to be in synchronism, since the variations possible are confined to a limit not exceeding one-fifth of the width of any regular segment.

The apparatus is readily started by starting the fork and rotating the vertical shaft *F*, and the adjustment of the two apparatuses

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is completed at the other station *Y*. At that station the operator also starts his apparatus and closes the switches at *M* and *N*. By the means already described the operator at *Y* can tell which apparatus is running the faster, and he then proceeds to adjust his own apparatus, until he is aware of the synchronism of the two, by the tell-tale strokes at *V* and *W*. It is found convenient in practice to make the resistance at *S* in the shape of a box of resistances, so as to readily vary the amount of resistance normally included in the local circuit.

A very important and beautiful feature of this invention is found in the manner in which the correcting impulses are rendered effective when the relay *U* leaves its back stop, as the corrections are thereby rendered practically instantaneous; whereas, if they were not made effective until the armature of the relay had been drawn to its front stop, the action of the correcting device would be sluggish. The adjustment of the armature of the relay *U* is very delicate, and it therefore responds immediately to any correcting impulse; so, too, the spring of the relay *V* is of sufficiently high tension to enable its armature to move almost instantaneously to its back stop.

Should the trailing arm at one station be moving more rapidly than that at the other station, it must soon overtake the trailing arm at the other station and bring them both into such relation to the battery connected 9's, and the extended correcting 10's, that the correcting impulses will thereafter maintain them in practical synchronism.

Should the main line between the two stations be accidentally broken, the synchronism would of course be destroyed; but on connecting it again, the instruments would of themselves, within two or three minutes at the most, again come into synchronism without the intervention of the operators.

The correcting impulses we have described are retarding ones, and are only called into play when one instrument runs faster than the other. Mr. Delany has slightly modified his apparatus, so as to make the correcting impulses accelerating ones, that are only called into play when one instrument runs slower than the other.

In this connection it may be well to state that numerous devices by means of which synchronism can be obtained, in connection with substantially the apparatus before described, have been discovered by Mr. Delany, and are fully protected.

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We have described four sets of independent circuits simultaneously established on the same line. It is evident, however, that by increasing the speed of rotation, fewer contacts during a single rotation will suffice for the practical operation of the ordinary Morse circuits, or by increasing the number of contacts in the circle, a much greater number of circuits may be obtained, so that the subdivision of the line into a greater number of circuits may be effected, without diminishing the speed of working.

An essential feature of the invention, without which it cannot be practically operated for long distances, consists in separate contacts, as shown in Fig. 8, placed between the contacts on the table F^1, at each station, and connected together to the ground, so that the line, being put to the ground before each completion of the circuits, will be freed from the greater or less static charge, which is very apt to be present in all lines of any considerable length.

Though the synchronous-multiplex system, as we have seen, is somewhat complicated in its apparatus, it is far simpler in its operation, and requires far less delicate adjustments than are essential in the quadruplex system. The difference between the two in this respect will better appear, when it is known that in the quadruplex system a change of electrical condition, equivalent to an increase in the length of the circuit of ten miles, is sufficient to throw it out of balance, and thus stop all communication; while in the synchronous-multiplex system, a change equivalent to five hundred miles may be instantly thrown on the synchronously operated wire without destroying the synchronous rotation of the trailing arms, or interrupting the various circuits.

The possibilities that suggest themselves as naturally resulting from the solution that Mr. Delany has made of the problem of obtaining and maintaining, at distant stations, practically absolute synchronism, are indeed, bewildering, and justly entitle this gentleman to a place among the world's great inventors.

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A paper read at the Philadelphia Meeting of the American Institute of Electrical Engineers, October, 1884.

THE SCIENTIFIC CITY STREET.

BY ROWLAND R. HAZARD, PREST. GRAMME CO., NEW YORK CITY.

Electricity, in its modern application, is both solving and creating problems. For example, it affords the only method by which the public streets may be used for rapid intramural travel without diminishing the value of property and imposing serious public burdens, while it intolerably disfigures the same streets, with its unsightly and dangerous aerial conductors and supports, which constitute an æsthetic and material nuisance of great magnitude.

Broadway, New York, is the most notable American example of the injury it inflicts and the benefits it offers. For many years engineers have been employed in devising methods for converting its roadway into a rapid transit subterranean thoroughfare; a multitude of plans have been devised, but all have failed to attract financial support or allay local apprehension and opposition, for the reason that no effectual method of removing the products of combustion by mechanical means could be devised, those adopted elsewhere not being successful, or not adapted to the limited space available. No openings in the roadway would be permitted, and many ineffectual attempts have been made to secure ventilation through what was known as the "area" between the sidewalk and the building; meanwhile the area has disappeared by the widening of the walk and the vault itself has become of great value, so that time has increased and not removed the difficulty. Further, as the products of combustion, smoke, ash, cinder, sulphurous acid gas, are heavier than the atmosphere, and the air of the subway damper and cooler than external air, even the most elaborate and expensive systems of ventilation would have proved inadequate to their complete removal. Electricity, however, dispenses with combustion within the subway, and, therefore, a structure which is constructed with reference to dryness, and the continuous passage of a current of external air, wherein the trains are worked by electricity, is freed at once from all the objections to a subway, is the safest, the most comfortable, convenient way, and provides for the fastest possible city travel.

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Meanwhile, a general committee on electrical underground communication was formed, representing twenty-one corporations, and a sub-committee was appointed, under the chairmanship of Dr. Henry Morton, of the Stevens Institute of Technology, to study and report upon the practicability of disposing of all electric wires and conductors underground, the accumulation of poles and wires having become a public nuisance. This committee received its instructions May 7, 1883, and reported March 15th, 1884. The report was long, learned, and elaborate, involving in its preparation an immense amount of labor in examining devices and collecting testimony from all sources. The summary reads as follows:

"No system submitted to or investigated by the committee seems to fulfill all the requirements so satisfactorily as a properly constructed tunnel of sufficient size to admit the passage of workmen and access to the wires within it. Connecting with this tunnel, conduits of sufficient capacity for lateral wires could be constructed as described.* The multiplicity of subterranean structures in this city might tend to operate disadvantageously, if not to prohibit the construction of such a tunnel, unless the same were arranged to accommodate the gas, steam, and other systems, as well as the electric wires. The deteriorating influences of steam and gas would, however, be apt, by destroying or impairing any system of insulation, to render the success and reliability of any system of conduits in the lower portion of the city questionable."

The first capital requirement of a great thoroughfare is—the accommodation of traffic, sub-divided into several classes. An ideal street should provide a smooth foot-way for the pedestrian, an even and noiseless carriage-way for vehicles, *and both of these ought to be unobstructed by any permanent or immovable thing whatever.* The present surface impediments will be doomed whenever the citizen obtains access to one example of unobstructed street surface. It must also provide for the travel of the hundreds of millions who wish to avail themselves of a more rapid or a cheaper method, and it must do this without appropriating the surface. The "elevated" road is therefore a temporary and clumsy device for accomplishing this end. It provides the facility, safety, rapidity and cheapness required, at an unspeakable

* See p. 17 of that Report.

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sacrifice of space, quiet, comfort, convenience, health and comeliness. The tramway is the least objectionable form so far devised to meet a part of this demand, and is capable of very great improvement in respect of speed, steadiness, comfort, convenience and economy when the motor supersedes the horse, and a good pavement permits the use of a slightly grooved rail. There remains the vast mass of rapid, long-distance travel, not now provided for at all, and the rapid short-distance travel which the tramway cannot develop sufficient speed to accommodate on Broadway, or upon any narrow and crowded thoroughfare.

There are, then, two distinct demands which the requirements of modern life make upon the sub-surface street, which it is the object of the "scientific street" to supply. Broadway is taken as the standard, and reference is made to the plate for illustration. The total width of the street (80 feet) is marked "Public Property." The private fee is shown in black, marked house-line, and is beyond this line. The side-walk is called "City Permit," for the reason that while the title is in the public, it is—underground—almost uniformly in the exclusive use of the abutting proprietor in fee, under license or "permit" from the city. The parts marked "area" and "vault," cover 18 feet from house line to curb line (colored yellow). Neither the one nor the other is disturbed by the lines of railway tunnel, or the galleries for pipes and wires.

The roadway between the curbs is 44 feet in width, and this furnishes all the accommodation required for all purposes. It is divided into two sections, the one, centrally placed, affords accommodation for two "way" and two "express" tunnels, within 35 feet, and is called the "permissive section" (colored red). The sections on either side are 4 feet 6 inches (colored blue) and called the "compulsory sections," because the existing impedimenta of the street must be disposed of at that point of access to the abutting houses. By this disposition of the street all requirements are fulfilled. A smooth, noiseless and unobstructed surface is provided for pedestrian and vehicular traffic, express and way trains for rapid transit, permanent housing for sewer, water, gas, steam, pneumatic, electric conductors and pipes, with access throughout for inspection, *and in all cases in immediate contact with the premises where the connections are to be made.* In neither express or way stations is private property taken, nor at any point does the structure abut private premises, even during construction. The section selected for illustration is

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north of Dey Street, where the existing obstructions are greatest, including the pneumatic tubes of the Western Union Company, the heavily "packed" pipes of the Steam Heating Company; and where provision for 4000 electric wires is required.

The method of construction is as follows: street excavation is effected in sections, and is governed by the extent and character of the traffic. A uniform platform of concrete, about two feet in thickness, floored by half-inch of Trinidad asphalt, is first laid, extending across the street at the maximum base depth of about 17 feet, forming a foundation for the whole structure. Upon this is erected the external vault wall (A A), securing to the abutting proprietor the permanent use of the whole vault and area undisturbed throughout the standard section. This vault wall is fitted while under construction with suitable connections for gas, steam, electricity, sewer and water at every house. This wall is also the external wall of the galleries, arranged adjacent to either curb (B B). The galleries are sub-divided longitudinally and continuously, by beams riveted to their internal and inserted in their external walls. Access throughout is provided at the termini and stations, and they are calculated for access to, housing and inspection of the tubes, pipes and wires. The electrical conductors are arranged anti-inductively, upon shelves riveted to the roof and gallery beams, as shown at C. There being no permanent floor above the foundation, the pipes in either gallery are accessible from above or below. Street opening for repair, replacement, or connection is thus wholly obviated. The internal frame supporting the galleries is formed by iron columns, placed four feet apart, and coincident with those forming the outer wall of the way railway tunnels. These columns are composed of two angle-irons riveted, and rest upon a continuous granite foundation. The space remaining between the pipe galleries, which in Broadway is thirty-five feet, is disposed in four railway tunnels, for the accommodation of an up way (D) and express (E), and a down (F) way and express (G) train. These tunnels are formed by five rows of columns each composed of four angle-irons, arranged longitudinally four feet apart, resting on a continuous granite base (H), the spaces between the columns at the foundation and the roof being filled by a panel composed of a tough, non-resonant material, secured by clamping-bars to elongated flanges of the columns, free but reinforced top and bottom. This panel fulfills a double function, it completes the tunnel for purposes of ventilation, and

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it prevents resonance, which might be caused by the rapid passage of a train through a tunnel with metallic walls. The roof is supported, and the whole structure tied by beams placed four feet from centres (J), which extend across the entire span, bolted at every eight feet to the tunnel columns, the ends being inserted in the vault wall. Upon these beams the steel ten-inch-span buckle-plate roof is laid and bolted; over this is a two-inch skin of Trinidad asphalt, as a protector from chemical contact and dampness, and as a slight cushion. Above this is placed six inches of concrete, which completes the permanent street. This structure as a whole contemplates the minimum of excavation, the maximum of capacity, the greatest number and most equal distribution of points of support, and consequent maximum of firmness and steadiness in use.

The railway tunnels form open cylinders from station to station, and the trains being of approximate cross-section constitute loose pistons always moving in the same direction; the obvious effect is the establishment of a ventilating current, dependent for its force upon the approximation of cross-sections and the speed of the trains; as the products of artifical combustion are excluded from the tunnels the requirements of ventilation are reduced to a minimum, and perfectly performed. The traffic-rails and the electrical conductor-conduit are bolted to the same steel tie (L), which arrangement secures perfect alignment, the tie being permanently set in the concrete foundation. The modern wood pavement now used in London and Paris, should be substituted for the noisy granite. This is constructed upon the correct theory that the surface is not an enduring part of the street, but that it bears the same relation to it that a woolen carpet does to an ordinary floor, that is, that it provides a comparatively temporary, soft and agreeable surface for wear, while it protects the floor itself from destruction. This pavement, like a carpet, is easily and cheaply repaired or renewed, and provides at once a smooth, easily cleaned and noiseless surface for traffic. Stations for way trains are approached from side streets, by entrances placed at the curb lines, the passage being faced with white enamelled brick, while the platform is placed in the space occupied in the standard section by the pipes and wires (they being specially arranged at stations), and a portion of the vaults only, but in no case any part of the area. The express stations are "double decked," and occupy but little space inside the curb

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line. There are entrances to stations at twenty two streets, between the Battery and the Hudson River terminus, at Vanderbilt avenue.

The steam plant for generating electricity for the railway service provides ten thousand horse-power, and the passenger capacity of the road will be about equal to that of the entire elevated railway system, as now worked. The railway carriages will be of unbreakable material and of standard gauge, so that they may be worked over the lines of any connecting trunk railways, which may provide an electric-conductor between the traffic rails. The devices of many electrical engineers and inventors will be employed in the complex designs for moving, switching, signaling, braking, lighting and regulating the numerous heavy trains required by these fast services.

Modifications of this specific design will be required under the variety of conditions imposed by varying widths and grades, but I venture to hope that its realization on Broadway will lead to the adoption of the sub-way for rapid travel in cities to the exclusion of any surface structures whatever. Meanwhile, an electric equipment for both elevated and surface roads, which is entirely within the present resources of the art, will diminish their offensiveness as far as is possible in the nature of things.

Note.—In the standard sections the disposition of pipes and wires in the galleries is: water-main, M: water distribution, N; sewer, O; gas-main, P; gas distribution, Q; street gas, R; steam pipes, S; pneumatic tubes, T.

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Read at the Philadelphia meeting of the American Institute of Electrical Engineers, October, 1884.

AN EXPERIMENTAL METHOD OF STUDYING THE DYNAMO MACHINE.

BY PROF. C. F. BRACKETT, PRINCETON, N. J.

I propose to give a short account of a method of experimentally investigating the dynamo machine, which has been devised and put in practice in the Physical Laboratory of the College of New Jersey. Its principal feature consists in the use of an exploring coil, by means of which it is easy to determine the relative value of any point of the magnetic field in which the armature revolves.

(1.) When the field magnets are excited by their normal current, generated by another machine, the armature of the machine under investigation being removed. (2.) When the field is modified by the presence of the iron core of the armature revolving without the usually accompanying coils. (3.) When the field is modified by the action of the coils of the armature revolving without their iron core, but carrying the current which usually traverses them. (4.) When the normally constructed armature is in operation in the production of the current in the ordinary way.

In order to estimate the energy consumed in any given case, the machine has its field-magnets balanced on knife edges, as I have elsewhere pointed out. The couple required to hold the magnets in opposition to the couple tending to make them revolve and the measured velocity of revolution enables us to determine the power expended in any given case.

The special arrangements are as follows:

(1.) The armature is removed from the arbor and in its place is secured a wooden hub, to which is attached the exploring coil, the latter having the same form as one of the coils of the armature though it may consist of one or of many turns of fine insulated wire, the number being determined by the conditions involved in the case under consideration. One end of the wire of the exploring coil enters a hole in its side and passes along the axis of the arbor, which is bored out for that purpose, and comes out centrally at its end, where it is soldered to a short cylindrical wire of steel, which is fixed by an insulating plug to the extremity of the arbor and concentrically with it. This steel wire passes through the

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side of an iron cup below the surface of mercury which it contains. The cup is supported by an insulating stand. The other end of the wire of the coil is soldered to the single narrow bar of a commutator cylinder which is fixed to the arbor and so arranged that it can be set coaxially, but so that a radius passing through the bar shall make any required angle with a radius passing through the exploring coil already described.

A divided circle fixed to the field magnets enables this to be done conveniently. A spring or "brush," insulated from the metal of the machine, is so adjusted that it shall touch the bar at the instant it is passing under it. If a wire join this spring to the mercury in the iron cup there will be a closed metallic circuit at the moment when the brush is in contact with the commutator bar; and since the coil is moving through the magnetic field, due to the field magnet, there will be at that instant an electromotive force, and so a current set up in the coil. This is evidently repeated at every revolution, and, if these be rapid enough, the result will approach in character a continuous current.

If we introduce into the circuit a condenser it will be fully charged at the potential due to the intensity of the field at the point passed by the exploring coil at the instant when the commutator coil is in contact with the brush. The condenser may be discharged through a ballistic galvanometer and the deflection noted. If, now, the commutator be so set as to be in contact with the brush when the exploring coil is passing another point in the field, whose angular position with respect to the first is known, and the observation made by means of the condenser and galvanometer, we shall have the relative value of the field at this point. We can proceed in like manner to determine the potential at as many points in the field as we desire. We thus have the necessary data for plotting a curve that shall show the distribution of the free magnetism of the field in which the armature of the machine turns when it is present. Instead of the condenser and the ballistic galvanometer, the quadrant electrometer may be employed more conveniently. It is in this case necessary to see that the electrometer is not affected by charges which have their origin in the friction of the belt which drives the machine. Proper care being taken to avoid such accidental disturbances, we may evidently plot our curve from the direct readings of the electrometer.

(2.) An exploring-coil is now placed on an iron ring, in all respects similar to that employed in the construction of the normal

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armature. And the ends are joined in exactly the same way as before. The coil is driven with uniform speed as before and the several observations are taken in the same way, and the result is plotted. The resulting curve shows how the magnetic field due to the field magnets is modified by the presence of the revolving iron ring.

(3.) An armature, in all respects similar to the normal armature of the machine, except that it is wound on a wooden core, is now placed on the arbor. An exploring-coil is wound upon it properly as before. The commutator brushes of the machine are put in place and adjusted, so that the current from the feeding machine shall traverse not only the magnets but also the armature. Now, on causing the machine to revolve with uniform velocity, as before, we can find the necessary data for plotting the curve representing the magnetic field, as modified by the presence of the revolving coils together with the currents which traverse them.

(4.) The proper armature of the machine is now put in place and an exploring coil is wound upon it as in the last case.

The proper connections are made and the readings of the electrometer, as affected by the coil in the different positions which it is successively made to assume are taken. The curve plotted from them shows the character of the field as modified by the action of the armature. It is obvious that we may now use the method of exploration here pointed out to determine what are the modifications due to different speeds of revolution. Also we may employ it to determine the proper form of the "cheek pieces" of the field magnets, the proper amount of iron to give the best results, and a great variety of other matters that will readily occur to one. The exact method of joining the ends of the exploring-coil to the electrometer which is here pointed out need not be followed in every case, as alternate methods will suggest themselves.

DISCUSSION.

Mr. George C. Maynard in the chair.

The Secretary:—I would like to ask Professor Brackett this question, whether there is any source of error in the use of the coil upon the wooden ring due to the counter-inductive influence of the field magnet upon the inner portion of the coil, that is, that portion of the coil that is nearest the axis?

Mr. Brackett:—On that head I will say something that will interest I think the gentlemen present. It is found, when we put

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in the Gramme ring, wound on a wooden core instead of an iron core, and drive it within field magnets, excited to the very same intensity as in an ordinary case, that whereas I should get driving it three thousand turns per minute, instead twenty Amperes, the normal current, I get about six Amperes, and in an opposite direction. Do you comprehend the answer to your question? The current is reversed when I use a wooden core. That is precisely the condition involved in the question of Mr. Keith. For here having no iron present, I have simply the return wire at this point.

Now, speaking directly to the point, I have to say, it is in that case the differential effect between one of these and the other, and if the same set of circumstances exists that differential effect may be presumed to be pro rata to the difference of area—take it all the way round. So that whatever may be said it does not depend upon the correctness, or interfere with the correctness of the distribution of the lines of force, not the slightest. But it does completely mislead the student who supposes that he is going to have a current in the same direction; he will have it in the opposite.

MR. KEITH:—Why?

PROF. BRACKETT:—I rather you would not ask me that question.

MR. SPERRY:—I would like to ask you another question as to the ratio of Amperes.

PROF. BRACKETT:—About twenty in one direction; six in the other. That is twenty-six degrees difference. One is in the opposite direction, twenty Amperes, proving the current is in the other direction.

MR. KELLY:—The negative current does not absorb the power.

PROF. BRACKETT:—It is a very curious result, and a striking one.

MR. KEITH:—Mr. Chairman and gentlemen, this to me is a very curious result. The paper is a very interesting one to me, and I am in hopes of being able to carry out this line of experiments on some machines that I have as yet in my head. And I would also remark that his mode of exploring the external magnetic field is a very good one. This afternoon there will be presented a method of exploring the magnetic field by Mr. Mailloux, using an induction coil and a telephone, and drawing his deduction from the tone or the note which is made in the telephone by the various actions which take place in the external field.

Speaking in my official capacity as Secretary, I hope we will have a good attendance when that paper is read.

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A paper read before the American Institute of Electrical Engineers, Philadelphia, October, 1884.

EARTH WIRES; OR, THE EARTH AS AN ELECTRIC CIRCUIT COMPLETER.

BY THOS. D. LOCKWOOD, ELECTRICIAN, AM. BELL TEL. CO.

To earth-dwellers, and especially to that portion of the race who are practically interested in the form of molecular motion, which we call Electricity, there is no element or adjunct of electrical science more important in many respects than the terrestrial ball itself, when we consider it in its relationship to the electrical circuit—whether that circuit be inductive or conductive, we are impelled to the opinion that its consequence cannot be too highly estimated.

When used in the arts of electrical communication, it enables us to reduce one-half of the number of line wires, which would otherwise have to be used; and when we consider the immense number of wires that even now fill our streets and line our highways, we cannot fail to reflect upon what might have been, had we been compelled to provide a separate return wire for each telegraphic and telephonic circuit from 1837 until 1884. For not only does the earth assume the functions of a return wire for a multitudinous number of circuits, but when the line wires exceed a few miles in length, the earth return actually completes the circuit in a way which admits of a much smaller expenditure of electrical energy than would be requisite in a line between two points an equal distance apart, connected by a continuous wire circuit; since the resistance of such an earth completed line should not generally exceed more than half of that of a metallic circuit connecting the same two points.

The first instance on record, where the earth or a portion thereof, in the form of water, was used deliberately, as an electrical conductor, to complete an electrical circuit, dates back to July, 1746, when Winkler, of Leipsic, both charged and discharged a battery of three Leyden jars through an insulated wire, thirty-seven and a half yards long, the wire being laid along the bank of the river Pleisse, the waters of which constituted the return part of the circuit. Winkler ascertained by this experiment

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that the effects of the discharge were not perceptibly different from those observed when a metal discharging rod was used.

About the same time, Le Monnier, of Paris, made similar experiments, and discharged Leyden jars through the water of a tank in the garden of the Tuileries.

We find from Priestley's "History of Electricity," that in England, shortly after the above experiments, Dr. William Watson carried out a number of others in the same line, under the auspices of the Royal Society Committee. On the 14th and 18th of July, 1747, the first experiments were made, a wire being carried over the river Thames on Westminster bridge, the water of the river serving as a return path for the current. On the 24th of the same month, a similar trial was made in a circuit of two miles, at the New River, near London. Two trials were here made; in one of these the electricity successfully traversed a distance of 800 feet overland, and 2,000 feet by water; and in the other, the circuit comprised 2,800 feet of land and 8,000 feet of water. In August of the same year it was discovered by Watson that dry ground conducted the subtle force quite as well as water. Again, on August 14th, 1747, at Shooters' Hill, a circuit was experimented with, consisting of two miles of wire and two miles of dry ground. In all of the above trials the electricity was effectually conducted by the earth acting practically as a return circuit.

Finally, in 1748 and 1749, these results were verified by Franklin and De Luc. We may note here, by the way, that nearly all of the early proposers or devisers of early electric telegraphs, from Le Sage down to Dyer, had intended to employ the earth as a return.

It is also, however, to be remarked that all of the above instances were experiments with high tension electricity; and that thus, if there had been no examples in which voltaic circuits had been completed through the earth, our fathers might have been excused in waiting for Steinheil. But such examples are not wanting, and the conductibility of the earth with respect to chemically generated electricity was also known for a long time anterior to Steinheil.

In February, in 1803, Aldini sent a current from a battery of eighty silver and zinc plates from one side of Calais harbor to the other through a wire supported on masts, the return being

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through 200 feet of water. He also repeated the same experiment at Paris and Alford, using the rivers Seine and Marne.

Basse, of Hameln, in the same year made a series of experiments by which he fully established the fact that the earth could he used as a part of a voltaic circuit.

Erman, of Potsdam, somewhat later, verified these results in the waters of the Hamel; and eight years later (1811) Soemmering and Schilling performed almost identical experiments with a view to establish the feasibility of using the earth as part of any electric circuit.

These are the historical circumstances which form a basis for the present system of earth completed circuits; and we may clearly see, that as early as the beginning of this century, the fact that the substance of the earth in the form either of water or dry ground could be used as part of an electric circuit was well established.

In view of these circumstances, it seems very strange that the earth circuit was not used, or even with one exception proposed, for telegraphs, until used by Steinheil in 1838. It is rather difficult to see why a well settled knowledge of the above circumstances which, if acted upon, would at once have halved the number of wires required, was not utilized until so late, even by Schilling and Soemmering, who were two of the earliest telegraphic inventors, and who both, although instrumental in demonstrating the truth by experiment, failed to apply it to their telegraph system.

As we shall presently see by Steinheil's own writings, his idea, to use the earth as a return, was in a measure forced upon him, being an observation made of the result of an experiment tried for quite another purpose.

*Singularly enough, his discovery was foreshadowed in a letter signed "Corpusculum," dated December 8th, 1837, and published in the Mechanic's Magazine. This letter speaks of the numerous designs for telegraphs, which were then being brought forward, and says that he, too, formed one, and prepared a specification for it, five years ago, including a plan of making one wire only serve for the return circuit for all the rest * * * ; "*but even that,*" he goes on to say, "*might I think be dispensed with, where a good discharging train, as gas or water pipes, at each end of the telegraph could be obtained.*"

* Vide Fahie's History of the Early Telegraphs, p. 345. London, 1884.

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The *application* of the earth itself, as a return, and a *common* return circuit for telegraph wires, came about in this way:—

Prof. C. A. Steinheil, of Munich, had in the year 1836—1837 constructed a telegraph line, and devised a most ingenious system of operation for the same. In consequence of a suggestion made by Counsellor Gauss (who in conjunction with Prof. Weber was also a telegraphic inventor of no mean order), that the two rails of a railway might be used as conductors for the electric telegraph, Prof. Steinheil, in 1838, tried the experiment on the railroad between Nurnberg and Fuerth. He was, however, unable to insulate the rails properly, and he found that the electricity passed from one rail to the other through the earth. He then used one rail as the return wire, the direct line being an insulated wire, and found it to work perfectly, for the rail itself acted not only as a return, but also as an earth plate.

Subsequently, he discarded the rail, and substituted earth plates at both ends.

It must not for a moment be supposed that the intent of this paper is to belittle the deservedly great fame of Steinheil. If the experiments, which had gone before, affect him in the least, it is but to enhance his perception; since he first had the wit to apply to a practical use what so many had experimented upon and amused themselves with.

I regard his eminently practical application, as being one of the most important ever made, and it certainly gave the art of electric telegraphy an impetus which nothing else could have done; and has contributed immensely to the development and extension of the telegraphs of the world.

This extremely useful suggestion had two great immediate advantages; it halved at once the number of required wires, and since the earth compared with a long line has no appreciable resistance, it doubled the strength of the telegraphic currents; or in other words enabled an halved electromotive force to produce an equal current strength.

The remarks of Professor Steinheil upon this subject are still so pertinent that I make no apology for quoting them here. He writes:

"Quite recently I have made the discovery that the ground may be employed as one-half of the conducting chain forming the circuit with the line wire. As in the case of frictional electricity, water or the ground may with the voltaic current form a

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portion of the connecting wire. Owing to the low conducting power of these bodies compared with metals, it is necessary that at the two places where the metal conductor is in connection with the semi-conductor, the former should present very large surfaces of contact. Taking water, for example, which conducts two million times worse than copper, a surface of water proportional to this must be brought in contact with the copper, to enable the voltaic current to meet with equal resistance in equal distances of water and metal; thus, if the section of a copper wire is 0.5 of a square line, it will require a copper plate of sixty-one square feet surface in order to conduct the voltaic current through the ground as the wire in question would conduct it. But as the thickness of metal is quite immaterial in this case, it will always be within our reach to get the requisite surfaces of contact at no great expense."

When Steinheil made his discovery he, as well as other physicists, thought that the earth actually conveyed the electricity from one plate to the other just as a wire does.

This idea was strengthened by experiments subsequently made by Matteucci and Baumgartner, and it is no doubt approximately correct in the case of very short lines.

Later observations do not seem to confirm the correctness of this hypothesis, and it is thought now by the leading minds which have considered the subject, that the earth performs the part in relation to a voltaic circuit with which it is connected, of an extremely large conductor of almost infinitely large mass, capable of absorbing the electricity as fast as it is developed, and thus maintaining the ends of the conducting line at a potential of zero, and permitting the battery (one pole of which, that connected with the line, is a certain degree either of a higher or lower potential than the earth) to work and maintain a flow of electricity until its materials are exhausted.

The evidence is greatly in favor of the latter hypothesis; and I have no hesitation in adopting it in preference to the view which considers the earth as a real return conductor, bringing the current of every source back again to its starting point.

As Electrical Engineers, however, it concerns us more to know that we can in many cases advantageously substitute an earth connection for a return wire, than to speculate upon the why and wherefore of the fact, except in so far as such speculations aid us in determining the best and most efficient methods and conditions

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of such substitution. Although the resistance of the earth when used as a circuit completer is very rarely of much importance, it still has a certain value, which rapidly decreases as the length of the wire part of the circuit increases, and it is estimated that it becomes too small to be taken into account when the line is over 75 miles long. If therefore we have a long line we need scarcely regard the absolute resistance of the earth, which is in relation to the line wire infinitely small, and we may say that the resistance of the entire circuit is only half of what it would be were the circuit entirely metallic.

But if the line is very short, the resistance of its conductor is correspondingly small, and the resistance of the earth becomes a more important factor in the case, and we cannot therefore regard it as nil, without introducing an error of greater or less degree.

The late Count Du Moncel made observations which tend to show that the resistance of the earth under very favorable conditions is equal to that of a No. 8 line wire of about seven miles in length. When, therefore, the resistance of the line wire is not over ninety or one hundred ohms, it does not seem advantageous if we desire the best electrical results, to use an earth return. By reason, however, of the increased economy in material involved, we would generally use earth terminals for an ordinary circuit as short as half a mile, unless the two ends of the wire, after the stations were all passed, could be brought conveniently near to one another; especially if satisfactory earth connections could be obtained. The last consideration brings us to another point: In addition to the absolute resistance of the earth itself, there is also more or less resistance between the plates and the earth. Here we may very properly recur to Steinheil's view and regard the earth for a time as a return wire, and the earth plate as a joint or connection between the main and return circuit; and in consequence, as a joint between a good conductor and a bad one. This view shows us the necessity of the utmost care in making earth connections, and may be exemplified by assuming that we have to connect a copper wire to an iron wire of the same conductivity, but of course differing widely in size; the iron wire we may assume is No. 8, has a diameter of 165 mils, and a resistance per mile of about 13 ohms per mile. A copper wire of almost an equal degree of conductivity is No. 16, which has a diameter of 65 mils; the diameter of the iron wire is thus about two and a half times that of the copper wire, and its sectional area

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is about six and a half times greater. If now we should bring the ends of the two wires squarely against one another, it is clear that more than five-sixths of the area surface of the iron wire would not be touched at all by the copper, and would not therefore aid in making a good point. The conductive lines of the joint are only equal to a smaller section of the iron wire.

Such a joint is of course very defective, but if the copper were enlarged so as to cover the entire end of the iron wire, the whole section of iron is utilized, and the joint is perfect. Applying this idea to the subject in hand, as described by Steinheil; inasmuch as the relative difference between ordinary iron line wire and the earth is at least one million, we find that the iron should at the junction be expanded to at least one million times its original surface, or the joint will be defective, for in practice the terminal connection of a line with the earth is virtually that of a joint. But if the two ground plates are of sufficient size for each of them to bring a surface a million times greater than that of their iron wire section into contact with the earth, the joints as compared with iron are perfect.

Thus we see that if we do not bring a knowledge of applied electricity and its laws to bear, even in the little matter of terminal grounds, we may introduce considerable unwarrantable and unnecessary resistance into an otherwise good line, and we shall then have a line which can never be worked economically.

The ground terminal of a telegraph may well, on account of its importance to the entire circuit, be regarded as the ground in another sense—the ground work or foundation upon which the entire modern telegraph system rests.

The ground or earth wire, of course, is always used to complete a circuit, but under many and varying conditions.

The earth wire may be used as a terminal for a single line, for a few lines, or for many lines.

It may be employed for a regular testing earth at a station, or for a temporary testing earth between stations in times of circuit trouble. We find, moreover, that the earth wire is also essential as an attachment to the lightning arrester or guard with which we protect our delicate instruments from the attacks of electricity in its most impressive form.

Sometimes also it is found necessary to protect the telegraph poles themselves by lightning rods, so that even the lightning rod itself, long regarded as the exclusive property of the charlatan and

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the electric quack, in its character of a ground wire, demands the consideration of the electric engineer.

Terminal Earth Wires.

In our large cities, good earth can always be obtained upon water or gas pipes, so that the idea of the Mechanic's Magazine writer, already referred to, is realized. Moreover, in many city buildings, at the present time, earth for many purposes can be obtained on almost any metallic surface to be found in the building, notably the pipes of steam heaters or radiators. It is always best to use a water pipe, if obtainable, because piping is often defective in conductivity at the joint, and in the water pipe the liquid itself aids in conducting the electricity. If gas pipes only are to be obtained, an attempt should be made to connect the wire thereto outside of the meter (this especially, if there be but one meter in the building); as otherwise the removal of the meter severs the connection with the earth entirely. If several series of water or gas pipes or both are at hand, I would make assurance doubly sure by connecting the earth wire with all of them.

In any case, the pipe should first at the point of attachment be filed quite clean and bright. A good earth may then be made by first winding a long stretch of copper wire of small size, say No. 16, smoothly and very tightly round the brightened pipe, until about six or eight inches of the pipe is longitudinally covered. This may be tightened up by passing the last few convolutions through one another, and it should be then well soldered to the pipe, leaving a loose end of about eighteen inches. This end should be spliced by a long and neat joint to a No. 6 or 4 main copper wire, which should previously be wound smoothly round the pipe, some eight or ten turns. The spliced ends may now be laid over the convolutions lengthways, and the whole again soldered. The large copper wire leads through the instruments to the line. This forms a good and reliable earth connection. The trouble with terminal wires is that they are frequently too small.

Earth wire clamps to be screwed to a pipe, and which are furnished with a binding screw for the wire are very good, provided they are made with a sufficient amount of longitudinal surface, which may be brought in contact with the brightened pipe, and fitted with a tight screw which will not work loose.

If a large and long clamp cannot be obtained, a number of

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small ones may be used, and all should have a movable plate of copper or brass between the ends of the clamping screws and the pipe, so that not the screw ends only, but a good surface under them can make the contact with the pipe.

In many places, especially in the country and in newly settled districts, there are still no pipes, and an earth plate has then to be buried.

Bars or wire ropes are by no means as effectual as earth plates.

These plates ought always to be made of copper, or of zinced or tinned iron.

These materials are recommended not on account of any degree of conductivity which they possess, but because their metallic surface is much longer maintained.

Ordinary iron, rusts through much too quick to be any use.

The plates should never be smaller than three feet by four, and they ought to be about one-eighth of an inch thick.

To make a first-class earth, two large insulated copper wires, say No. 6, should be used to connect with the plates, and holes being made through the plates, the ends of the wires may be threaded through; about four holes for each wire will do. The wires should then be soldered to the plate at each hole.

In setting the plate, the hole should be dug until damp earth is reached, and the plate must be set vertically, so that its upper edge does not come above the level of dampness. All strain should be taken from the wires, and above the surface of the ground they may be soldered together, and then to a single iron wire leading to the office and line.

I hold that all points of an earth wire from the instruments to the earth should be well insulated, so that no electrolytic action can arise, due to leakage, at midway points. When the earth wire is to serve as the terminal of many wires, it should be as large as can be conveniently handled. Telephone exchanges of many wires can readily be operated without any main terminal earth wire, as each wire finds earth by way of all the others. Some offices are so worked. We prefer, however, an earth terminal of the highest character, as it is quite conceivable that half of the lines may be in use at one time, in which case the joint resistance of the remainder may be rather high; certainly much higher than the normal joint resistance.

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Testing Earth Wires.

These, when at offices, ought to be as perfect as terminal earth wires, especially at terminal or testing stations.

At way, or intermediate stations, this is not so important, as there the earth wire should only be used in the event of circuit trouble. At the terminal station the earth wire may be constructed in the same way as the method described for the terminal. Such a long splice, if a pipe is used, is however, not absolutely so essential. To insure accuracy of testing operations, the resistance of the testing earth wire should be frequently measured.

At a way station, earth can sometimes be temporarily obtained from the rails of the railway, but the earth plate is the only plan I should recommend for a permanency.

Lightning Arrester Earths.

These should be made of the largest copper wire that can be procured and handled, as they sometimes have to convey very heavy discharges. They are to be connected according to the descriptions already given, except that when located in a cable box, they may be attached to the cable armor instead of to a plate. If possible they should invariably terminate at a different plate from that of the terminal wire.

Pole Lightning Rods.

These are for the protection of poles. They may be led from a point about two feet above the pole, down the side thereof, being secured by staple, and terminate in a plate buried in damp earth at the foot of the pole. Unless, however, good earth is made the pole is safer without any wire. When used, they should have branches running out on the cross arms to within half an inch from each insulator.

Any earth wire can readily be measured for resistance in like manner with any other conductor.

No earth wire and plate should measure more than ten ohms.

In conclusion: If earth wires are employed, they should always be of the same metal, as otherwise they will generate currents themselves by virtue of the difference in potential between the two plates, one of them being electro-positive to the other.

I have long been impressed with the pre-eminent importance of this subject, and while I can scarcely hope that I have done it the justice it deserves, I have tried to make it both practical and interesting, and it may perhaps incite others to give us something better worthy of your attention.

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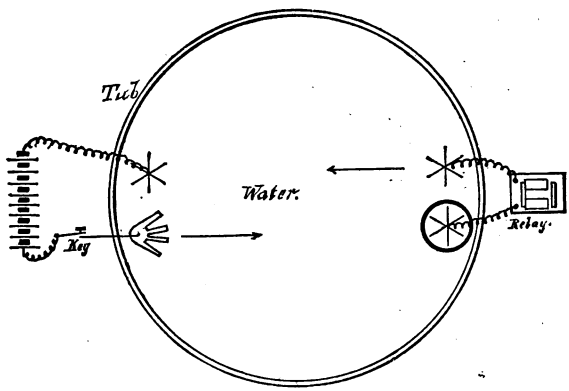
A paper read before the American Institute of Electrical Engineers, at Philadelphia, October, 1884.

TELEGRAPHING WITHOUT WIRES — AN EXPERIMENT.

BY S. J. M. BEAR.

MATERIALS.—A tub of water, ten cells voltaic battery, two copper earth-plates, one zinc earth-plate, and one porous cell, containing a copper plate, immersed in a solution of sulphate of copper, making the fourth ground connection; a relay, or other receiving instrument, of about two hundred ohms resistance, and a transmitting key.

ARRANGEMENT OF PARTS.—All of the battery outside of the tub, with key in circuit, is connected with the water at one part of the tub, and the relay is connected to the water directly opposite. The zinc plate of battery is connected with copper plate in water, and copper plate of battery is in connection with zinc plate in water. These battery terminals in the tub may be quite close together, but must not be in metallic contact with each other. The relay has one terminal in connection with a copper plate in the water, and the other terminal connected with the copper in porous cell in the water; and these two last connections may also be close to each other.



Now, by opening and closing the battery circuit outside the tub, signals may be heard from the relay in response.

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Thus, regardless of the relative distance between the ground-plates, electric impulses are transmitted through the water without any insulation between the outgoing and incoming current.

In this way, two continuous currents may pass each other closely in opposite directions at the same time, in the same conductor; or, in other words, the same current passes itself closely in the same conductor; or, if you please, the positive and negative currents are uninsulated in the same narrow circuit.

Then, what prevents the battery current from crossing over between the earth-plates at the sending station? A part of it does so short-circuit, whether an uninsulated wire is used for half the circuit, which we shall see further on, or as above without any wire.

The resistance of water between the sending earth-plates is probably but a few ohms, and yet we have enough of the current out and returned through many times greater resistance of water, to operate the relay, itself of two hundred ohms resistance.

Then, what is the resistance between the sending earth-plates, that causes so much of the current to take the apparently longer route? May it not be the resistance of opposing polarity? For here we have the circuit at the sending-end from the zinc terminal of the battery to and through another active zinc in the tub before it reaches the copper terminal of the battery. It is assumed that the copper earth-plates in the water in the tub are practically inactive, that is, not generating any electricity, but only performing the simple functions of conductors, or circuit connections. What is meant by opposing polarity, is the electrically active plates of same name repelling the passage of a current direct between a pair. On the other hand, we have the inviting or down-hill route from active zinc plate in tub to the active copper plate in porous cell—this copper plate made active by the sulphate of copper liquid surrounding it.

It is not that the conducting body of water is so much wider or larger between the sender and receiver than between the sending earth-plates, that we have this result; for, separating the sending earth-plates the same distance as to the receiver plates does not perceptibly weaken the working of relay.

Now, we will use an uninsulated conductor, the same as a bare copper wire, for half the circuit; or, more properly, as shown, "ground" one-half the circuit, that is usually insulated, by making metallic contact between the inactive coppers, and add any num-

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ber of such plates, giving all the surface connection possible with the water for establishing a "ground," and yet in this case nearly all the current generated in battery goes the apparently longer route, by the resistance of relay, and having the smaller surface connections.

Neither is the relay operated by the divided single cell in the tub—the active zinc at battery and the active copper at relay, completing its circuit through relay, conductors, battery, key, active zinc, water, and active copper, back to relay—for, by cutting off all the main battery, we find this divided, or tub-cell, fails to operate the relay, even on the same adjustment as the "without wire" plan. I believe this theory is correct, that it is the repulsion of the polarized active ground plates of same name that resists the short-circuiting, as connecting the zincs of two cells together, and the coppers of same cells together by wire, will not produce good voltaic action. Then we may assume that the outgoing and incoming currents in the tub repel or bend each other apart, like the lines of force in a magnetic field; and, continuing the magnetic analogy, we have for the sending earth-plates north pole repelling north pole for the short circuit, while through the relay circuit we have, like the attraction between a north and south pole, the inviting route.

I believe that a certain fraction of current flows to relay, represented by one as a numerator, and the number of cells as a denominator; that is, a fixed part of current cannot overcome the resistance of same polarity, viz.: if a main battery of ten cells is used, one-tenth of its current cannot short-circuit in above arrangement, and if twenty cells, then one-twentieth flows out to receiver; the smaller portion of current being weakened by the resistance through which it flows, the same as if it had an insulated circuit.

DISCUSSION.

Mr. BEAR:—Now, I will add that with the wire plan, or "ground" plan, I have frequently connected all the coppers for which I had room in the tub. With these (indicating) several coppers, half a dozen or a dozen, we get surface, taking up all the room there (indicating). I have put plenty of common salt in the water, as it is well known to reduce the resistance, that, if possible, I might allow but little of the current to flow across the longer circuit, and, therefore, not leave anything to operate the relay;

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but the relay would operate much stronger that way than by the "without wire" plan. What I mean is, that to make the ground connection here as good as possible by saturating the water with salt, so that no more salt would be absorbed in the water, the relay would operate very strongly; I should judge at least half the battery current flowing to the relay. I would further add, that I have never had the opportunity of testing these two different plans, based upon, as I consider, the same principle. I have never had an opportunity to test it with instruments of precision; I have only used common telegraphic instruments, a relay and a sounder; but I tested it through salt water, water of the Atlantic Ocean, in a little bay, with about a half a mile of uninsulated wire, but not having a strong battery force—three or four cells only—I got all the results from it I expected to with such a small battery, but they were very weak. I used a sounder, and with three or four cells to the battery and half a mile of uninsulated wire, I was only able to affect the sounder with the very weakest adjustment; it would not affect the relay at all, I presume, by my not having battery enough, but the sounder certainly was affected at the distant end through the uninsulated wire immersed in the ocean water. I had a common laborer hear the sounder operate, so that it was not my prejudice that supposed that it operated. Those are the severest tests I have put the apparatus to. [Applause.]

The CHAIRMAN:—Gentlemen, you have just heard Mr. Bear's very interesting remarks. A discussion is now in order on the subject.

Mr. JAMES KELLY:—I wish to ask a question. The sounder was certainly affected, you say, and the relay not at all. I would like to ask how the sounder was affected without affecting the relay?

Mr. KEITH:—He had no relay.

Mr. BEAR:—That is a very pertinent question, because telegraph operators, these gentlemen know, generally use a sounder and relay together, but in this case I only used a sounder in a circuit by itself. The sounder was in the main circuit; I did not use the relay at all at the time; I used the sounder.

Mr. PARTZ:—I don't think the explanation is quite satisfactory. The gentleman assumes that the current passes through water, that it takes the trouble of passing through the relay in order to return, while it might have a much easier route and go through the water; I don't think the current will take that trouble. I

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believe the current goes from one electrode to the other. The current that you get through the relay is simply an induction current. You want a much stronger battery in order to work this than you would by simply pushing the current through the water. That could be done with a very few elements. You have got this section of water into these lines of force, therefore, you have got to push your current with such force that it extends considerably into the water in order to produce an induced current; and that is what you get through your relay; that is my opinion.

Mr. BEAR:—In reply, I would acknowledge my ignorance, if that current in the relay is produced by induction. The current in the relay is continuous. As I understand induction, when I would close the key of the battery there might be a temporary impulse, an instantaneous impulse of induction through the relay; but in this case the relay remains, as the operators call it, "closed." Therefore I take it it is not an induced current.

Mr. PARTZ:—Yes; but you don't get any manifestations until you work your key.

Mr. BEAR:—I just stated, and I intended to make it plain, that I did get a manifestation of the current by having, as every telegraph operator understands, the sounder or relay closed, and being properly adjusted. That is evidence that there is a continuous current flowing through the relay.

Mr. BAILEY:—I would like to ask the gentleman who has given this exhibition how closely those electrodes leading from the battery to the key have been placed together.

Mr. BEAR:—Yes, sir; I will state, one of our most prominent electricians made this *experimentum crucis* himself. I had not made it before, I believe; he took the copper and the zinc and interlocked them like my fingers (indicating) as closely as possible without touching, then separated them as far as possible. But apparently it made no difference in the operation of the relay when that test was made.

Mr. BAILEY:—Was that test made while it was in the tub?

Mr. BEAR:—Yes, sir.

Mr. BAILEY:—Do you know the distance? Was it the same as it is in this tub?

Mr. BEAR:—Yes, sir; but I took a different battery. I had ten cells of the common large size—main battery cells, the common blue vitriol gravity battery.

Mr. BAILEY:—Then, I understand you it was many times the

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distance between the electrodes leading from the key and the battery; many times that distance, from them to and through the relay and return?

Mr. BEAR:—The relay circuit was many times greater resistance than the short-circuit of the battery, between the transmitting earth-plates.

Mr. BAILEY:—That is exactly what I am arriving at. As I understand you, there was no perceptible difference in the action of the relay.

Mr. BEAR:—There might have been a difference, which would have been shown by a galvanometer.

Mr. BAILEY:—The relay was working with equal promptness in either case?

Mr. BEAR:—Yes, sir.

The CHAIRMAN:—It seems to me that this whole question is one of relative resistance, and had Mr. Bear had the benefit of a galvanometer to increase the amount of his knowledge upon the subject, he perhaps would have arrived at a different conclusion.

Mr. MAYNARD:—I would like to inquire of Mr. Bear whether he has used this system for actual communication by the Morse system over some considerable distance; whether he has not actually telegraphed with the Morse instruments and without insulation for a long distance?

Mr. BEAR:—No, sir; I have not.

Mr. MAYNARD:—Another question. What do you consider is the practical application of this system?

Mr. BEAR:—I consider its practical application to be in assisting in the insulation of telegraphic circuits.

Mr. MAYNARD:—Is there any reason why you cannot telegraph across the ocean as well as across the tub?

Mr. BEAR:—From my theories, and I have studied the subject for several years, I do not know of any reason why not; and I find that the best authorities upon the subject, those that we find published even lately (I believe since the opening of this exhibition), have suggested the placing of one earth-plate in the northern region and the other away south. But that is on the old, or Morse, plan of telegraphing by relative resistances, as I understand it. This, my method, does not depend on the relative resistances, as we understand the term resistance or conductivity.

Mr. PREECE:—What does it depend upon?

Mr. BEAR:—I believe it depends upon the counter electro-

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motive force, or polarity; the meaning is the same. As the north pole of the magnet will repel a north pole, although if one north pole is strong enough, it will overcome the weaker north pole; so that if this electromotive force of the main battery is high enough, a great portion of it will overcome the opposing electromotive force of the plate of the same name.

Mr. KEITH:—I had understood from Mr. Bear, previous to reading his paper, that he had experimented with this in ponds of considerable size, so that his experiment has been in the water, and on a larger scale than here shown. I think that is what Mr. Maynard wished to get at—whether you had actually carried on an experiment of any considerable size; that is, larger than the tub?

Mr. BEAR:—Oh, yes. By the wire plan, but not without wire. I got so much better results with uninsulated wire, and you may readily imagine, by my explanation of this point, that I wanted commercial success. But my idea was that if I used this "without-wire" plan it would only give me one circuit; whereas, we want many circuits. And if I succeeded in operating successfully the uninsulated plan, then I could use any number of circuits close together, so long as they were not in metallic contact.

The CHAIRMAN (Mr. W. D. Sargent):—I would ask if Mr. Preece desires to make any remarks upon the subject?

Mr. PREECE:—I think the society would, perhaps, like to have the details of a practical experiment bearing on this subject; and I am sorry I was not present during the time the paper was read, for up to the present moment I quite fail to perceive in what this differs from our oldest notions of the mode of communication across water without wires.

It is now, I am almost ashamed to say how many years, but it was in the year 1853 (and 53 from 84 leaves 31), 31 years ago, there was a Mr. Lindsey, a Scotchman, who came to London with the notion, shared in by a great many people since, that he was going to make an enormous fortune, because he had discovered a mode of transmission across water without the aid of wires. He came to the electrical company, to which I was then attached, and made an experiment exactly similar, so far as I see, to that which has been made here. We gave him a tank about the size of this table, about 8 or 10 feet long, and about four feet wide, and in that tank he placed four copper plates, arranged exactly as shown here, but the instrument used was not a relay; it was an ordinary Wheatstone signal needle; and we certainly got effects through it,

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which showed distinctly that it was possible by such an arrangement as that to transmit electrical signals across water without the aid of wires at all; and the experiment was sufficient to justify its being tried on a larger scale. So he was allowed to experiment, I think, upon the river Tay, I can't quite recollect what river it was, but it was, at any rate, some river in Scotland. Two wires were located some few miles along the banks on either side, and the experiment was repeated, and was again successful. The only effects on the galvanometer were evidently less in actual practice than they were when the experiment was in the insulated tub or tank, such as we gave him. The result of that experiment was sufficient to prove the whole theory of the thing, but it was seen that it was not practical with the then instruments. I took a little interest in the matter at the time, but I had the impression that such an experiment was described, I think, in a very old and valuable book published in this country by Mr. Albert Vail; I think Mr. Morse, or somebody, if not Mr. Morse himself, made a very similar experiment herein. Anyhow that experiment remained in abeyance for a great many years, and it was only when the telephone was brought into existence, with its excessive sensitiveness, that we were induced to repeat the experiment.

It happened that a cable connecting the Isle of Wight, in the South of England, to the mainland broke. The Isle of Wight is a place where the Queen has one of her residences, and we are very careful in maintaining telegraphic communication complete there. The Isle of Wight is shaped something like that. [Illustrating on blackboard.] Here is Southampton, there is a spot of land going out there called Hurst Castle, Southampton Castle coming up there, and there is the town of Portsmouth. [Indicating.] There is the town of Southampton, and there is Hurst Castle. This is the Isle of Wight, and this is Newport, the Queen's residence, and that place is Ryde. [Indicating.] Now wires come from Southampton to that place, and the cable crosses there; they go from Newport into Osborn and Ryde. A few go to Southampton and Portsmouth. Now, here was a very good opportunity to test this very fact; and I had the cable earth-plates placed in the sea, and the wire was carried to the end of the pier, with the cable plates there and there. [Indicating.] So the circuit was completed, with about a mile of sea there, and six miles of sea over there. [Indicating.] The operators were here. They had a telephone here, and a telephone there [indicating],

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and no sound could be obtained from the voice. With a bugle a faint sound was heard; but when we inserted a buzzer, something like one of the tuning-forks used by Mr. Delany to maintain his vibration, we obtained a buzzing sound, and by the use of the tuning-forks we succeeded in sending currents so rapid as to make sonorous vibrations, and then sounds were distinctly heard there. But when the key was manipulated by the operator at either station, then it was quite possible to transmit signals by making and breaking these buzzing sounds, and thereby to continue the correspondence and to continue the telegraphic communication. Unfortunately for the experiment, this cable that was broken was renewed and repaired that very day the experiment was made, so that we really never carried out this practically. We simply made an experiment as an experiment; but the experiment was so satisfactory that if this cable breaks again, then we shall certainly during the time that it is broken maintain telegraphic communication with the Isle of Wight through the sea circuit arrangement until the cable is repaired.

Now, there is just one little point in this that rather removes it from the category of Mr. Bear's experiment, or Mr. Lindsey's, and that is, that across here you have not absolutely an unbroken piece of water, but you have a cable. The cable was broken probably for the distance of a few fathoms, but at any rate there was a conductor separated by a few inches or a few feet, and it maintained communication across there. On the other hand, here you had an undoubted length of six miles.

Now, I do not see, at present, I may be wrong, in what respect this experiment differs from the one that has been described to you. If we have a river with banks running parallel, and we have an earth-plate there, and a conductor there in each bank, it is quite possible to transmit a current through, when the resistance of that length compares to the ratio of that length, and from all theoretical reasons, it is very easy to give the relation determining that and to show the condition of the strength of current; but I gather from Mr. Bear that he thinks the counter electromotive force is the cause of the matter. I have not the least doubt that it is. But it simply does so because the electromotive force, the reverse electromotive force, becomes exactly the same as his resistance. If you are using a bridge, and you are testing a current, that circuit may have an earth current in it, and if the earth current flows in the same

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direction as the current you are testing, then your resistance is less than it ought to be; but if that earth current flows in the contrary direction, then your resistance is increased and is greater than it ought to be; so that the influence of counter electromotive force in a current is exactly the same as answers to the true resistance. This experiment has been described to you as in point of fact and theory exactly the same as that which governs the experiment I have given, and is the same as that which is supposed to be within the knowledge of those who read works on electricity, or even in the knowledge of those who make a practical application of the telegraph instruments. That experiment is simply an experiment for illustration of the practical demonstration of the truth of the theory by which we are able to communicate across water without the aid of conducting wires.

Mr. KELLY:—If he has drawn this diagram correctly I don't see how he obtains the electromotive force.

SECOND DISCUSSION.

The CHAIRMAN (Mr. George C. Maynard):—Mr. Partz desires to make some remarks on the subject of telegraphing without wires, a subject that was introduced by Mr. Bear yesterday.

Mr. PARTZ:—As the subject was brought up before you, I thought it might not be out of place to set forth a little scheme of mine of telegraphing without cables through the water. I mentioned the matter yesterday as a sort of curiosity for the time being to Mr. Preece. I will make it as short as possible.

Suppose that this is an irregular section of the globe through its Northern Hemisphere; supposing that here you have Halifax, there Vancouver's Island, or any other point on the Northern Pacific coast, there the mouth of the Amor River in Siberia, and that a point on the west coast of Ireland. Now we have a continuous insulated conductor from Nova Scotia to Vancouver's Island. We have another insulated conductor from the Amor River to Ireland. Now, supposing the current passing through that conductor in that direction, that current must necessarily go through that conductor in that direction, that current must necessarily go around the globe, and consequently you can telegraph without a cable. The current would certainly not go back to Vancouver's Island or to Nova Scotia, that is, take land conductor, as it has a much easier way the other way.

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As I said before, it may be a mere curiosity for the present, but we do not know always what these will finally result in. Mr. Delany, with his system, has certainly shown us that more can be done with one wire than was thought possible, and that any number of messages can be sent at the same time. The thing will look different when it is accomplished. Such a line might extend around the globe. You might work, say from the Congo River to Central America, by having a relay station at St. Helena. From Central America through the Pacific Ocean, having relay stations at the Islands and over to China, and from China then by land, and by short cables to the Congo River. For that continent I do not think will remain very long dark, and there will certainly be a telegraph somehow put through. A line might be established from the Cape of Good Hope to Buenos Ayres, and from Buenos Ayres to Valparaiso, and from Valparaiso to the South Sea Islands and Australia. I would like to hear any objections to that, if there are any. I have no doubt but that it will be put into practice, perhaps, before we arrive at 1900. Perhaps in twenty or twenty-five years, something of that kind will be arrived at, because it is rational.

Mr. KEITH:—There is one very pertinent objection to it, and that is that it has not been tried.

Mr. PARTZ:—It may be tried at any time now. There is nothing to interfere with it being tried.

The CHAIRMAN:—I would like to ask one question. If this theory is true, will it not be quite practical to try it on some small lake and settle the question before you attempt to cross the ocean; will not that settle the theory just as well?

Mr. PARTZ:—I don't know whether that could so easily be tried on a small scale. It would be rather difficult to try it on a small scale. You could not get a circuit of that kind, it would be necessary to take in the globe.

Mr. BEAR:—Mr. President, I believe the conditions are similar in a small body of water or earth as in a large—the largest, as the ocean, as suggested by Mr. Partz; or in a lake, or in a tub of water, the same conditions will obtain, I believe. This is simply the old method, which I quoted yesterday, of Professor Morse. Whether others were before him or not, I do not know. This is a matter of relative resistances, familiar to us all. That if two routes are offered for the electric impulse or current it will divide, according to Ohm's law, as Mr. Partz truly says, instead of run-

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ning the greater distances between these earth connections, it will take a shorter distance, and it is perfectly rational and ought to be tried.

The CHAIRMAN:—Gentlemen, as we seem to have gone back to yesterday's business for a moment, I thought it might not be out of place to correct one misapprehension, which was brought up yesterday by the paper on underground wires read by Mr. Callender, and which I have heard expressed about twice a day for three or four weeks, and that is that the underground wire question has been settled once for all in Washington. The electrical people seem to have gotten the idea that somebody there has settled the question, and they are very fond of referring to that.

The facts are as follows: That the underground question in Washington has been thoroughly unsettled. I think some six or eight years ago Captain Green, who is quoted as the man who settled the question there, came to me to see what books I had on the subject. In looking over what I had, he picked out several volumes of the Journal of the London Electrical Engineers' Society. In that journal he found some report made by Mr. Preece on laying underground some telegraph wires between London and Manchester. He said at once that that settled the question, and that there was nothing more to be said, and he wrote a report to that effect. I think that he has never changed his opinion since then. Whether he has obtained any additional light on the subject, I would not undertake to say. At all events, the District Commissioners, who are the controlling military power of the District, have been issuing orders about semi-annually ever since, that no more wires should be strung overhead. Since they gave such an order the number of poles in the District, I suppose, have been doubled and quadrupled a good many times over, and what is of a good deal of importance, the poles have been erected by the National Government. The District government has always been erecting poles, and the number erected by the government has been very much larger than all the other poles in the city together, and the government has been setting up poles almost up to this day, and I think that they contemplate setting up more poles. During all this time the Commissioners have never, to my knowledge, asked Congress for a dollar of money, even to try any experiment with underground wires. But the great pressure that they have kept upon the private corporations has very much hindered the setting of poles, and has brought about quite a number of experiments

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with underground work. Two or three of the telegraph companies have laid some small number of wires in various ways underground. Some of them have worked, and some of them have not worked. The Waring Cable Company have, within the last year, been laying some few wires—three, four, or five wires, to connect some of the departments, at their own expense. The Telephone Company, under the pressure of the authorities, and under the general pressure of the demands for a greater number of wires, has made an experimental line of several hundred wires for about a mile with moderate success. They are preparing to lay some more wires, but the fact remains that the wires in Washington are not all underground. There does not seem to be any immediate prospect that they will go there. So that the gentlemen who are anxious for this, that the wires can and will work underground, will do well to look to some other city than Washington.

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A paper read before the American Institute of Electrical Engineers, at Philadelphia, October, 1884.

CHEMISTRY OF THE CARBON FILAMENT.

BY EDWARD P. THOMPSON, M. E.

The object of this paper is to treat of the manufacture of the carbon filament from a chemical point of view, pointing out the chemicals from which it is to be made; the chemical actions which take place according to principle or experiment, or both; and the conditions which are necessary in order to obtain a filament of the maximum density, hardness, elasticity and homogeneity.

The principal lamps now being largely manufactured and represented at the Exhibition, and in which the filaments differ from one another by distinct chemical reactions which take place in their manufacture, are the Edison, the Swan, the Weston and the Stanley and Thompson lamps.

The Maxim lamp falls under the Swan and Edison in this classification, being distinguished from them only in the hydrocarbon treatment.

The filament in the Edison, Swan and Maxim is made from the same chemical substance, long known as cellulose, the formula for which is $C_6H_{10}O_5$. It possesses allotropic states in the forms of linen, cotton, paper and woody fibre, which differ widely in their physical properties, but show the above formula, by quantitative analysis, with the exception of a small percentage of impurities, which impurities may be neglected on account of their not being the cause of the difference of physical properties.

When subjected to dry destructive distillation, the hydrogen and the oxygen, together with the carbon in part, are separated only to unite again in different proportions and different groups to form new compounds, such as hydro carbons CH_4, CH_3, C_2H_2, etc., and the two oxides of carbon, besides numerous secondary products and oils and tars and pyrogallic acid and wood spirits, and in fact all the products which are evolved in the manufacture of coal gas, and more yet, due to the fact that the composition of cellulose is more complex than that of coal.

Very unfortunate it is that, during the carbonization of carbon filaments, much of the carbon is lost in the form of carbonic oxide and dioxide and hydrocarbons.

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By calculation from the formula, it is observed that the carbon in cellulose occurs by weight to the extent of 44 per cent. only of the weight of cellulose from which it is obtained. The calculation is here shown, thus:

$C_6H_{10}O_5$

C_6	$6 \times 12 =$	72
H_{10}	$10 \times 1 =$	10
O_5	$5 \times 16 =$	80
		162

$72 \div 162 = 44$ per cent. carbon.

Although the cellulose becomes reduced in weight by carbonization, yet the specific gravity is not diminished. On the contrary it is increased considerably. A bamboo fibre will float on water, while the filament made therefrom will sink; so also with other forms of cellulose. This is on account of a contraction which takes place by the effect of heat and chemical reactions. Nevertheless, the carbon filaments are by no means as dense as if the carbon of the cellulose entirely remained after carbonization. In kilns for the manufacture of charcoal, the carbon which is removed is a larger per cent. than that removed from carbon filaments during their process of manufacture. This greater loss is due to its combining with the oxygen of the air, which is not wholly excluded from the kiln.

Filaments, being so small, may be baked in a crucible and the air removed or displaced by sprinkling fine graphite or carbon dust about the forms containing the filaments, or by the introduction of coal gas through a pipe. The former process is probably preferable, as it allows the highest temperature possible, while coal gas deposits large quantities of coke, which is likely to clog and build up the filaments irregularly when the temperature is maintained any length of time above the kindling point of coal gas. By either process, however, or by both combined, the oxygen of the air is practically excluded, so that there is no loss of carbon from this source.

By experiment, I have found that the carbon filament of the Swan, Edison and Maxim lamps does not weigh 44 per cent. as much as the cellulose filament from which it is produced. Calculation, it will be remembered, shows the above figure. In the experiment the air was carefully excluded. The carbons on an average weighed only 35 per cent. the weight of the cellulose,

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showing a loss of carbon of about 8 per cent. This is a very serious loss, as it causes the carbon to be 8 per cent. more porous than were no carbon lost at all. Further experiment showed that the loss can be reduced by certain precautions in baking, in the case not only of vegetable fibres, but also in that of animal matter.

The precautions taken were to raise the temperature of the crucible (which can easily be accomplished by a gas furnace) to a point just below that of the melting point of cast iron.

This increasing of the temperature should be made so gradually as to occupy several hours, and then should be maintained an hour or so at this temperature. Afterwards, it may be raised to the highest degree possible for one or two hours more. By this method of baking, it was found, as was expected, that the carbon occurred in a quantity approaching 44 per cent. within 4 per cent. instead of 8 per cent. The experiment proved further the principle that hydrogen will unite with oxygen at a lower temperature than carbon will unite with oxygen or hydrogen. If the temperature were regulated in exactly the right manner, there would be no loss of carbon. As this cannot be done even in the laboratory, and as it cannot be done with certainty in the factory, this method of saving the carbon cannot be of much use commercially.

Mr. Swan has endeavored to make the carbon dense by making the cellulose of cotton thread dense. The same percentage of loss of carbon occurs, however, as in ordinary cotton thread. The cotton or linen thread in this process, as carried on in the factory at Boston, is taken from one set of spools and wound upon another set of spools, which are situated at such a distance from the first set as to allow space for several large tanks, the first of which is full of sulphuric acid, one third water; the second with water, and the third with dilute ammonia, and the fourth with water.

The thread, by passing alternately below and above rollers, is caused to pass through the liquids in the order given. The sulphuric acid produces no chemical change, as is shown by subsequent analysis. It does, however, produce an important molecular change, so that the thread is three times as strong in tensile strength, is non-fibrous, of a pearly lustre, and as flexible as before treatment, its color still remaining as before. The rollers are rotated at such a rate as to allow the chemical to act on the thread about 15 to 20 seconds. Passing next into the tank of water, the excess of acid is washed away. The ammonia in the

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next tank neutralizes the remainder of the acid by turning it into sulphate of ammonia. The last tank washes away the sulphate, so that the thread is wound upon the spools, having only to pass between sponges to dry it. One physical change not mentioned above is the change of dimensions. The thread is larger than previously and is not of a regular and uniform diameter, showing that it could not have been acted upon alike at all points, which is not surprising when it is remembered that only 15 seconds are allowed and that the acid is itself weakened in its action as each molecule attacks the thread, causing acid of different strengths to act on different parts.

Temperature of the acid, as well as its specific gravity and time of action, very often produces worthless material for carbonization. The diameter is made uniform by drawing it through a die-plate, whereby it may not only be made uniform, but may also be made into various smaller sizes than the original.

The parchmentized thread is next wound upon two carbon rods supported at the end in holes bored into pine sticks. One of the sticks is removed during the winding, as it facilitates matters; especially as an instrument is employed which was invented by Mr. Swan for the purpose. It is wound about these two carbon rods in such a manner as to give the double curve noticed in the Swan filament.

I have often wondered whether Mr. Edison has ever tried to parchmentize the bamboo filament. It is already denser than cotton thread, as well as stronger, and yet nearly as flexible. There seems no reason why it cannot be thus changed in its physical nature by means of strong sulphuric acid. It is cellulose, just as truly as cotton, linen and paper are cellulose. For many years it has been known how to parchmentize paper, and yet it was only five years since Mr. Swan succeeded in making parchment from linen and cotton. I think that it would pay somebody to parchmentize wood. The new article would be valuable in many departments of industry.

I have referred heretofore to the subject of the loss of carbon, due to the process of destructive distillation; and now I wish to refer to it more particularly, and to point out the means which have been adopted in the lamp invented by Mr. Stanley and myself. Our object was to obtain as dense a carbon as possible, not only by producing such a chemical action during carbonization as would leave all the carbon as a residue, but also to introduce an

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additional amount of carbon by depositing the latter from a foreign substance introduced into the filament before carbonization, which substance would also be acted upon by chemical treatment. It may be mentioned that the carbon disappears by combining with the oxygen and hydrogen. Our process is found to cause all the oxygen to unite with the hydrogen, thus leaving all the carbon as a residue, and consequently leaving a carbon denser by 8 to 4 per cent. The process can be applied not only to vegetable fibre, but also to animal matter, which latter is employed in the manufacture of the lamps under exhibition. It is a well-known principle that sulphuric acid has a very strong affinity for water, and also for the elements of water when both elements occur in the same compound, as is the case in both animal and vegetable substances. An illustration of these principles may be observed when the acid is mixed with water. They immediately combine, with evolution of much heat. Also, if strong acid is poured upon sugar or syrup, the latter rapidly becomes hot, and intense chemical action is seen to take place. The final result is, that whereas we had sugar and acid, there now appears only a mass of carbon. The acid has taken away the hydrogen and oxygen in the proportion to form water, leaving free the carbon according to the following equation:

$$C_6H_{22}O_{11}+H_2SO_4=C_6+(H_2SO_4+11H_2O).$$

This reaction may be made to take place either by the strong acid, as indicated, or by weak acid plus heat. Take some sugar and moisten it with the weak acid, and heat gradually. If the acid were not present it is evident that the sugar would melt and turn into a thin liquid; but with acid and sugar mixed as described, the sugar turns into carbon by the application of heat without first melting, and the result is found to be a fine quality of the purest carbon; and if the acid and sugar are used in the right proportion, it is found by experiment that the amount of carbon remaining is equal to the amount calculated by the formula, which is as follows:

$C_6H_{22}O_{11}$.

$$\begin{aligned} C_6 &= 12 \times 6 = 72 \\ H_{22} &= 1 \times 22 = 22 \\ O_{11} &= 16 \times 11 = 176 \\ & \qquad\qquad 270 \end{aligned}$$

$72 \div 270 = 30$ per cent. of carbon in the sugar.

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In the same manner it is found that sulphuric acid will blacken both animal and vegetable matter, and by the use of weak acid plus heat the substance is carbonized without loss of carbon and without destruction of solidity and density.

As our process involves these principles, and as the chemical actions have been verified by experiment and manufacture, it may be interesting and instructive to consider the process more in detail. The substance used may be any form of animal matter or cellulose; so that it will not be necessary to limit ourselves to the description of any particular kind of substance, further than to remark that we use animal matter, which gives a superior quality of carbon to that produced from vegetables. In the same manner as animal charcoal is found to be superior to vegetable charcoal in commerce, so it is found to be superior in electric lighting.

The substance is first prepared in the form of a thread. We form a mixture of sulphuric acid, water and sugar, by dissolving the sugar to saturation in a dilute solution of sulphuric acid. The proportion of water and acid is as 10 to 1. It may be noted here that this dilute acid will dissolve more sugar than the same volume of water by about 20 per cent. at the same temperature. The thread of animal or nitrogenous substance is wound upon large spools and immersed in the solution until every fibre is acted upon and until a chemical action has changed the character of the substance to some extent. This action is allowed to continue for about one week, while submerged in the liquid; but in fact it continues throughout the rest of the process, because the chemical preparation is not washed away, being allowed to remain in the substance during the carbonization. The excess of it is, however, wiped away by an apparatus invented for the purpose. The amount of the chemical mixture which is absorbed increases the weight by about 50 per cent., which represents an addition of carbon to a considerable extent, both on account of the addition of the total amount of carbon from the sugar and on account of the acid causing the retention of the total amount of carbon in the animal substance. When taken from the mixture and left to stand for several months it turns perfectly black and in truth commences to carbonize at the ordinary temperature, and, if left for years, would undoubtedly turn into carbon completely at the ordinary temperature. This is not, however, our process of procedure, although it is made to coincide with it as far as possible,

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i. e., it is carbonized as slowly as practicable. After being wiped as to the excess of acidulated saccharine matter, it is prepared for the oven as now to be described. This step of the process relates to that of being able to carbonize a larger number of filaments in a space scarcely larger than that occupied by the filaments themselves. In the preparation of carbon filaments, it has been customary to form the fibre of the material which is to form the basis of the filament into the desired shape, and to subject it while still retained in that form to sufficient heat to remove other substances than the carbon. Each filament has most usually been formed into the desired shape and treated separately. The process used in this lamp consists generally in supporting a large number of the filaments which are to be carbonized upon a single forming block, the contour of which is similar to that which it is desired to give the filaments; while thus held upon the forming block in their required positions, subjecting them to sufficient heat to effect their carbonization. The form of the block upon which the thread or filament of an indefinite length is wound helically is such that when the filament is wound upon it, it will be bent into the form of loops, which have the shape it is desired should be retained by the carbonized filaments; and the prepared thread, after being wound upon the block, is retained in position by means of string or wire, or, in short, by a ligature wound transversely across the same. When thus prepared, the filament is cut at such points that single filaments are left each in the shape of the form. They are prevented from falling off the form by means of the ligature wound upon the same. The forms with the fibre upon them are then placed in a drying oven, which is slowly raised to a temperature of not less than a 100 degrees and not more than about 300 degrees C., so as not to reach the point at which sulphuric acid is vaporized. The water in the fibre is evaporated by the heat very gradually and quietly, and the sulphuric acid remaining in the fibre and growing stronger through the withdrawal of the water and through the increase of the heat, attacks and carbonizes without loss the sugar which has been taken up by the fibre. As the process is gradual and as there is present the acid, the sugar carbonizes into a hard compact mass which, being in the pores of the fibre, builds the latter up into a solid mass. In other words, it acts as a carbonaceous ement, making the structure non-fibrous and non-porous. If the acid were not present the saccharine matter would melt and run

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away. At the same time with the carbonization of the sugar, the fibre itself undergoes a chemical change through the action of the now strengthened acid upon it. It perhaps is impossible to state the exact chemical reactions which take place; but it is known that the nitrogen of the fibre is almost entirely removed from it and the fibrine it contains is entirely converted into new chemical combinations closely resembling one another and all extremely poor in nitrogen, such as leucine, $C_6H_{13}NO_2$; glycocine, $C_2H_3NO_2$, and tyrocine, $C_9H_{11}NO_3$.

The cause of these reactions depends upon the fundamental principle that sulphuric acid has a strong affinity for the elements of hydrogen and oxygen in the proportion to form water. In this way the hitherto nitrogenous animal fibre is converted into an essentially non-nitrogenous substance which will not be exploded into powder during the subsequent furnace carbonization, as would be the case if the nitrogen originally present in the fibre were allowed to remain, but can be readily converted into a tough elastic carbon of high specific resistance. If the fibre were exposed directly to the action of concentrated sulphuric acid, or of dilute sulphuric acid strong enough to attack it, it would be dissolved and destroyed before becoming fit for carbonization. However, as the acid is taken into the fibre in a dilute condition and then gradually becomes stronger, the action takes place slowly and throughout the fibre, as there is no free liquid present in which the resulting new compounds are dissolved, they being retained in the body of the fibre.

After the sugar is carbonized and the nitrogen is removed from the fibre, the forms containing the filaments are removed and placed in a crucible in a furnace heated to a temperature somewhat higher than that necessary to carbonize vegetable fibre, or about 3,000° F.

In the process of carbonization, the last trace of sulphuric acid is driven off, and any nitrogen that may have remained in the fibre is removed in the form of one of the gaseous oxides of nitrogen, and the result is a purely non-nitrogenous carbon. So much for the chemical actions during carbonizations.

While the high heat of the furnace acts upon the ligature, it is also carbonized, but being of a weaker nature than the filament, it breaks instead of the latter when subjected to the strain due to carbonization. By the time it breaks at all, the filaments are so nearly carbonized that they retain the shape of the form and do

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not curl and twist as would be the case were they not held to the form by the ligature. The best material to wind the filaments upon as a form has been found after numerous experiments to be carbon cut from coke, or the ordinary compressed carbon cakes cut into the required shape. Among the various substances tried were iron, and some other metals having high points of fusion, lime and similar refractory substances and wood. When wood is used, it is not necessary to cut the filament into individual filaments until after taken from the furnace, because the wood contracts proportionately as the filaments shrink; but the wood, however well seasoned, does not shrink regularly enough to keep the carbons in good uniform and regular shape. When iron is employed, the carbons are not of as superior a quality; for the iron will not absorb such oily products of destructive distillation as are given off during carbonization. The best substance to use is carbon, which may be employed repeatedly indefinitely; which absorbs the liquids and gases liberated from the filaments, and which at the same time is cheap and easily made. It is usually preferable to so construct the supporting forms that each complete convolution formed upon the same will produce two carbonized filaments, so that by cutting the same upon the opposite sides of the centre of the block, two loops will be formed having their ends confronting each other. In some instances it is desirable that the carbonized filament should have a greater breadth at the loop than at the ends—*i. e.*, to have it horseshoe shaped and not exactly U shaped—and for this purpose it will be desirable to construct the double form of supporting block of less thickness through its centre than near its edges. In winding the carbonizable thread upon such a block, it will be necessary to provide some means for permitting the same to be drawn down by the winding strings into the concave surfaces thus formed. To accomplish this result, suitable blocks capable of taking up as much of the prepared thread as will be necessary to allow it to be pressed into the hollow spaces are laid upon the sides of the block while the thread is being wound. These blocks are then removed and the subsequent winding of the supporting ligature presses the thread downward into the hollow or concave spaces, pressing it tightly against the surface of the forming block. By this process of carbonizing the filaments, their shape is free from any twist or curls, being of a continuous and regular shape corresponding exactly with the shape of the forming block. The forms

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may now be taken from the crucible, and by shaking them over a box all the carbons fall off in perfect shape, resembling in almost every property steel wire. In a crucible 6 in. × 6 in. × 6 in., 1000 carbons may be baked, all of which may be obtained without danger of breaking one or of finding one of irregular shape.

It is well known that when animal matter is subjected to destructive distillation it swells to several times its natural size and leaves it porous, with only small trace of carbon, of a shape anything but that of the mass from which it was carbonized, and consequently unfit for use as carbon filaments, even when the greatest precautions are taken as to excluding all air and as to regulation of temperature. The reasons for this behavior of animal matter under heat are in consequence of the presence of nitrogenous substances and a large quantity of water, held both by absorption and by chemical combination. The nitrogenous compounds explode into gases, with slight but comparatively strong detonations, and the water turns into a large quantity of steam, both of which cause a swelling and numerous eruptions, while the nature of the chemical reactions causes the carrying away of carbon in the form of gaseous compounds. By the simple process of soaking the animal or other varieties of nitrogenous substances in a saturated solution of sugar, in dilute sulphuric acid, for about one week, and then gradually heating to the highest temperature, without previously washing out the chemical solution, there is obtained a carbon filament of high specific gravity, and of considerable elasticity, hardness and strength.

Another new departure in the application of the hidden principles of chemistry to electric lighting is seen in the manufacture of the Weston lamp. In one of the eighteen large volumes of Gmelin's treatise on chemistry, are discovered the principles of the Weston process; but from the principles as there stated, no one but Mr. Weston probably would ever have attempted to apply them to the manufacture of the carbon filament. It is only by his persevering energy and repeated experiments that he ever succeeded in making a sizable and homogeneous mass large enough to make even one filament.

In Gmelin it is learned that when certain nitrogenous substances, such as gun cotton, collodion and albumen, are subjected to the action of sulphide of ammonia, protochloride of iron or tin, or cupra ammonia, the substance will thereby be deprived of its

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nitrogenous compounds, and will be reduced to a composition approximately similar to cellulose. I do not quote this word for word from Gmelin, but only from my memory of about a year and a half. These reducing agents have a strong attraction for oxygen, so that when left remaining exposed to the air for a short time a yellowish precipitate is formed which consists of the oxidized reducing agent. Sulphydrate of ammonia has a strong attraction not only for free oxygen, but also for oxygen occurring in other compounds, so that when a nitrogenous substance is placed in the sulphide, the oxygen is taken away in part from the nitrogen, while the remainder of the oxygen and nitrogen form one or more of the lower gaseous oxides of nitrogen, which escape and leave the substance practically free from nitrogen. This is the result of our investigation towards the exact chemical changes which take place, and which may or may not be found to be correct by further experiment. At the time of Mr. Weston's announcement of his investigation in this direction, we tried the manufacture of some experimental carbons according to his suggestions. We noticed great difficulties in obtaining any appreciable quantity of the substance which he has decided to call tamadine. Upon pouring the sulphide upon collodion, the latter at once turned opaque and white in spots and appeared fibrous, while upon investigation it proved to be non-fibrous. At these spots it was considerably tougher than the original collodion, but not so homogeneous as the collodion. By flooding the collodion with an excess of the sulphide, the spots of the changed substance were larger; but by repeated experiments we found it apparently impossible to obtain a large enough quantity for carbonization in the form of a filament. It was apparent, however, that the difficulties were due to mechanical and not to chemical difficulties. I have since learned that Mr. Weston is obliged to use large excesses of the sulphide, to use it at a fixed specific gravity and at a constant temperature. The quality of the results is best appreciated by viewing the samples on exhibition.

DISCUSSION.

The CHAIRMAN (Mr. W. D. Sargent):—Gentlemen, before inviting discussion on this most interesting paper which has been read, I desire to say that I have the honor to announce that we have with us this morning one of the most distinguished electricians of the present day. It is perhaps superfluous to name him—William H. Preece, of the British Postal Telegraphs. I

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desire to say that we honor ourselves much more than we can honor him by electing him to honorary membership. I trust that we will hear from Mr. Preece on the various subjects that come before us this morning, and we shall be very much satisfied with any remarks that he may make. (Applause.)

Mr. WILLIAM H. PREECE, London, Eng.:—I am afraid, gentlemen, that nature has deprived me of a power which I once held rather prominently, and that is the power of blushing; for if that power had remained, I think the sudden surprise of the remarks of your Chairman would certainly have brought to my cheek those colors which are now only to be produced by an artificial agency. Anyhow, whether the color comes or not the sensation remains, and I feel a sudden rise in the number of vibrations per second on my part, which tells me that I am excessively gratified by the receipt of the unexpected compliment paid to me. I assure you that if there is anything I can do for the purpose of furthering the interests of this young society, which I would like to see flourish, my services will be most cheerfully placed at your disposal. (Applause.)

The CHAIRMAN:—Discussion, gentlemen, is now in order on this interesting paper just read by the Secretary. I understand that there are several gentlemen present who are very competent to impart information on the subject, and we shall be very glad to hear from them. Will Mr. Kelly favor us with some remarks?

Mr. KELLY:—I have nothing to say, Mr. Chairman.

Mr. KEITH:—I know that there are several gentlemen quite competent to either criticise or indorse the paper that has been read. It seems to me that only natural timidity prevents them from getting up and saying something. Mr. Weston's name has been rather prominently mentioned in this paper as to a process of treatment. Whether the process, as here stated, is true or not, I would like to know if we can get such information. I hope Mr. Kelly, who is with Mr. Weston, will give us some few remarks upon this subject.

Mr. JOHN KELLY:—I might say the plan employed is practically that described by Mr. Thompson, and the difficulties met with by Mr. Thompson, in attempting to follow Mr. Weston's process, were the same that we met with ourselves previously, and it took a long course of experiments before we were able to overcome them. Now the article is manufactured on a large scale, and of course we do not meet with them to the same extent, because the material is prepared in large quantities; therefore the

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products are alike all the time. But the irregularities he spoke of meeting in the manufacture are likely be met with pretty constantly, because you cannot get collodion to contract regularly. That is a fact which should be mentioned.

Mr. KEITH:—If I am allowed to get up on my feet again for the sake of getting information, I would say that Mr. Charles Stagl, connected with the Bernstein Electric Company, can give some information on the subject. The Bernstein lamp is a lamp of peculiar construction, and has excited a great deal of interest. It seems to me that Mr. Stagl might possibly, if he feels so disposed, give us some information as to the process of carbonization pursued by the Bernstein Company, or some information relating to the lamps.

Mr. STAGL:—I am very sorry I do not speak enough English so that I could explain it in the right way here for the society—especially this process which we are preparing. I am quite sure I have not English words enough so I could explain in the right way.

Mr. KEITH:—There is another gentleman, Mr. Knowles, who, I know, has been experimenting for years on the carbonization of filaments for the carbon lamps. I will say this, Mr. President, that we are banded together in a new society—we are banded together for mutual improvement and information, and it is only by every gentleman who knows something, more or less upon various subjects, getting up and telling us something of his own individual experience, that will enable us to make our meetings interesting and our proceedings worthy of publication.

Mr. KNOWLES:—I am not prepared to say anything on the subject to-day, but I hope at some future time to make it the subject of a paper

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A paper read before the American Institute of Electrical Engineers, Philadelphia, October, 1884; with discussion thereon.

DEPOSITING-VATS IN "SERIES."

BY H. B. SLATER, ELIZABETH, N. J.

Mr. SLATER:—Mr. Chairman and gentlemen of the Institute, I do not expect at this time to present anything new or startling, especially to electricians; in fact I did not think it would be of interest to any one until it was suggested to me a short timea go that such a paper would be of interest to the meeting.

The subject of which I propose to treat is "Electro-Depositing-Vats in Series." Not exactly to treat of the subject, but simply to relate a matter of personal and practical experience, in that which, probably, all of us who have been in an electro-plating establishment have noticed. If we have noticed carefully, we have found that there was a great waste of the power employed for the deposition of metal. It has been my experience during the last seven or eight years, in many parts of the country, to find a high power running to waste through absolute ignorance of the principles of the force which the plates were using, and where they were acquainted with the facts which would naturally lead them to use it aright, they were either too lazy or too indifferent to make a proper application, so as to use them intelligently. As I say, I do not expect to present anything new, but I will simply call attention to a few facts and laws, and give the result of my experiments in the practical working upon a factory scale—that with an ordinary amount of information upon the subject, any plater or any electrotyper can apply these same principles and perform work with a small amount of power, compared with that which is generally used in such establishments.

If a current be passed through an electrolyte, containing a metal in solution, the quantity of the metal deposited in a given time will be proportional to the strength of the current.

This can be demonstrated experimentally with the voltameter, as follows: Introduce a rheostat into the circuit, and by varying the resistance it will appear that the gas or metal, according as either kind of voltameter is used, is deposited in direct proportion to the current strength. If we double the total resistance in circuit, we shall have half the current, while, if we halve the total resistance, we shall have double the current.

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If several voltameters be connected in "series," it will be found that the law holds good for each one of the "series." The voltameter may be either the small experimental apparatus of the laboratory, or the large depositing-vat of the electro-plater; for the one is as truly a voltameter as the other, and the laws of definite electrolysis can be as well observed and carried out *practically* in the plating room, as *experimentally* in the laboratory.

The power consumed in electro-deposition is almost entirely used in overcoming the resistance of the circuit; viz.: the conductors, anodes, liquid and cathodes; hence any reduction in this resistance must result in a saving of power. This, of course, under conditions to be hereafter noted.

Resistance varies directly as the length and inversely as the cross-section of the circuit; hence by a decrease of length or an increase of cross-section we obtain a decrease of resistance, and according to Ohm's law a corresponding increase of current. It is plain then that with a given length of conductor, we can reduce the resistance to almost *nil*, or increase the length indefinitely, and still keep the resistance constant, provided suitable increase is made in the cross-section.

The resistance of an electrolyte depends upon the length of the liquid circuit, which is determined by the distance between the plates; and the area of the section of the liquid, which is determined by the size of the plates. It also depends upon the temperature.

I will now describe a "series" of depositing-vats in actual use on the factory scale, and working successfully for some time past.

Connected with a vat containing 200 gals. of metallic solution, I had a small dynamo machine. The work plated in the vat was all of the same size and kind, and sufficient to keep the machine constantly at work. The dimensions of the vat were: length, 6′ 6″; width, 2′ 6″; depth 2′. In it were three rows of nine anodes each, each anode being $8'' \times 12''$. One row extended from end to end of the vat at equal distances from the sides. The other two rows hung close to the sides of the vat, only one side of each of the side rows being exposed directly to the work. It will be understood that there were two spaces for work, one on each side of the middle row of anodes. As each side of the middle row of anodes was exposed to the work I had $6 + 6 = 12$ square feet, and on the other two only one side of each row $6 + 6 = 12$ square feet, giving a total of 24 square feet of anode

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surface. The distance between the plates or anodes on each side of the anode row was 15″.

The vat, with both rows of work filled up, held just 20 pieces, 10 on each rod. The articles to be plated were hung with their flat sides to the anodes, and as they were about 1″ thick it will be seen that the distance between anode and cathode was 7″. The resistance of the vat was .242 ohm between the terminals while full of work with the current passing. This included of course the—*e*. The E.M.F. of the dynamo = 12.32 volts after running 3 hours, and the resistance = .2 ohm. The resistance of the connections was practically nil, as the machine was close to the vat, and connected by a short, thick wire. By Ohm's formula we have $C = \frac{E}{R} = 27.87$ ampères. As the maximum current obtained was with an external resistance, equal to the internal resistance of the dynamo, it will be readily seen that there was very little waste of power.

On receiving orders to increase the output of work, it became necessary to increase the facilities for doing it, and an exactly similar outfit was placed side by side with the first one, including both vat and dynamo. I had experimented, about two years before, with vats in "series," and now resolved to put the idea into actual practice, as the work soon increased, so that the original output was more than doubled.

In each of the vats I placed another row of anodes, and so placed them that I had three spaces for work, instead of two, as before. This increased the anode surface by one-half ($\frac{1}{2}$) the original amount, viz., from 24′ to 36′, and as this increased the cross-section of the circuit in each vat by one-third ($\frac{1}{3}$), it of course produced a corresponding decrease of resistance. But by inserting this row of anodes the width of the vat was divided by 3 instead of by 2 as before. Originally the distance apart of the anodes was $\frac{30}{2}″ = 15″$, now it was $\frac{30}{3}″ = 10″$. The simplest calculation will show that these changes had reduced the resistance of each vat to less than 50 per cent. of its original value.

I now dispensed entirely with one of the dynamos, and connecting the two vats in "series" to the other dynamo, I set them to work and have every reason to declare it a success.

The vats are side by side, two (2′) feet apart, and the dynamo is placed between them at the end, connected by a short, thick wire from the + terminal to one of the vats, and by a similar wire from the vat on the other side of it to the — terminal.

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On measuring up the series the dimensions were now found to be as follows: The E.M.F. was assumed to be as before, 12.32 volts; for it was the original machine, and ran at the same speed. Also the internal resistance of the machine was the same as before, .2 ohm. The external resistance between the terminals of the "series" was now, however, .2018 ohm, which added to .2 gives a total resistance of .4018. By Ohm's law, $C = \frac{12.32}{.4018} =$ 30.7 ampères.

As a result of the arrangement in "series," we have nearly 31 ampères of current passing through each vat, and a total effect of 61.4 ampères, compared with 27.87 ampères from the same machine through a single vat.

Further additions to this "series" can be made, but as the working space in the vats is as small as is convenient, it would be necessary to increase the *cross-section* by making additions of vats in "multiple arc," to compensate for the increase in *length* of the "series." In the case of the two vats described above, the additions to the anode surface, and also the work, were made in "multiple arc," and in any further increase of the "series," additions can be made by placing vats side by side, and connecting anodes and work as though they were one vat; and for every increase in *length* by addition to the "series," a corresponding increase must be made in the *cross-section* by an addition in "multiple arc." These additions in "multiple arc" must not be carried too far, however, as the ampère current per unit surface will thereby be reduced beyond the value which gives a satisfactory deposit.

I would say this "series" here treated consists simply of two vats, since increased to four vats, changing the size of the vats; but this "series" is simply of two vats in series, with a very small machine. The machine used was a shunt-wound machine, and automatic resistance in the shunt, by which the electro motive force was regulated to bring it down to the same amount.

DISCUSSION.

The CHAIRMAN (Mr. W. D. Sargent):—Gentlemen, are there any remarks on this interesting paper just read by Mr. Slater. We are ready to hear from any of the members.

Mr. KEITH:—Mr. Chairman and gentlemen, as our honorable guest, Mr. Preece, has said to me, "This is your hobby," I may be supposed to be called upon to say something on the subject.

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What I have to say will be very brief at this time, because I have a paper prepared on this subject, embracing the laws which govern it, and some remarks as to the practical application in electro-metallurgy on a more extensive scale than that of simply plating, namely, the production of pure metals. This point becomes very essential in the economy of such a process, and I have investigated it very extensively since 1876, and have put it into practice in quite a number of instances, which I need not now rehearse. It is, as Mr. Slater has remarked, of great importance to the electrotyper as well as to the electro-metallurgist, because by it he is enabled to do a much greater amount of work, as it increases his battery power. In the case of nickel, which he especially refers to, there is necessarily a little increase in the power by reason of the fact that there is some chemical decomposition which takes place in nickel vats. Some hydrogen is deposited, so far as my experience goes, with the solution of the double sulphate of nickel and ammonia; there is some hydrogen deposited with the nickel. The oxygen is absorbed by the other side, but the setting free of the hydrogen requires energy, and wherever action is to be repeated, as in the succession of vats, just that increase which is the multiple of the number of vats is necessary to effect that kind of decomposition.

That is different in those cases where there is no deposition of hydrogen, as in copper-plating and electrotyping vats. In those baths there is no absorption of energy in effecting electrolysis; in effecting the solution of the metal at the anode, the exact equivalent of the energy is set free to that required for the deposition of the metal upon the cathode. I ask Mr. Slater if he has made any experiments as to the amount of energy that is required to effect the deposition of hydrogen in the several vats. I presume that he has, unless he has made some other improvements for the evolution of hydrogen which is produced.

Mr. SLATER:—I will say on that point that I have not the proper facilities for making extended trials in that direction. I have made some experiments, however, but what I have aimed to do is to reduce as far as possible the amount of hydrogen deposited. I think I have succeeded in that direction in a great measure by combinations in the solutions; that is to reduce the evolution of the gas. How far I have succeeded in that direction I am not prepared to say, not having the proper facilities for making the experiments. That will remain for some future work. I think,

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however, that in the solution produced by me at present the amount of hydrogen deposited as compared with the amount deposited in the sulphate solution is very small indeed. I came to the conclusion some time ago that it was hardly worth while to notice that in my practical work except for information.

Mr. E. A. SPERRY:—I noticed in the reading, a statement something like this, as I understand it, that the deposition of metal went on much better when the interior and exterior resistance was equal.

Mr. SLATER:—I would say in that regard that I have found that the principal difficulty in my work has been to bring down the resistance of the external within proper limits. Unnecessary resistance is, of course, a waste of power. To avoid useless resistance the dynamo was placed as close to the vats as possible, and all connections were made as large as possible, consequently the resistance was all in the actual work, and the work going on at its best.

Mr. E. A. SPERRY:—As I understand it, these conditions named are those that exist when the maximum amount of work is done, and it stands to reason that the most economical system would be with the greatest exterior resistance on the exterior circuit if sufficient ampère current would warrant the insertion of the vats. Ofc ourse too many vats would reduce the ampères of current, until the amount deposited per second, per minute, or per hour, would be such as would render it not an economical system. Other than from that consideration I do not see any reason for reducing the exterior resistance. That would interfere with the interior resistance of the dynamo.

Mr. SLATER:—The vats are so placed and connected, that the only considerable resistance is in the vats themselves, and by suitable arrangement in "series" and "multiple arc" the total resistance of the vats will not exceed the proper limit and the ampères of current will not be reduced.

Mr. KEITH:—Mr. Chairman, I desire to state the matter in this way: that if we have one vat of a given area of surface, say one square foot, and pass the current through it, we get a product of one. There is no expenditure of energy except the mere overcoming of the resistance of the circuit. If we add to the number of vats so as to place them in a series, we are obliged to increase the energy applied to effect the passage of the current in proportion to the resistance to the current implied by this addition of another vat. There is no more counter electro motive force

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chemically produced to be overcome. Now if we place two more vats in series and in parallel, so as to make a multiple series arrangement, as made and shown by these four squares, we then have exactly the same resistance as before. There is just as much current as before; there are two translations by reason of the series, and at each translation we produce the amount of electrolysis that is due to the current passing. In case we have four vats we divide the current between this two series, so that in each vat there is just half as much electrical action, or deposition of metal, as took place before. But we have four vats; four times one-half produces two, which is twice the deposit made before, with the expenditure of no more energy. In case of nickel decomposition, the setting free of gases which I referred to before, there is an increase in the energy necessary to pass the current through the vats in series, and that increase is necessitated by counter electro motive force produced by the evolution of the gas. I may say that this whole subject is to be treated of in my paper, and as it will probably be found that there will be no time to bring the paper out at this meeting it will duly be published in the proceedings, with diagrams illustrating the points. For the practical application of it I again refer you to the paper read by me before the Institute of Mining Engineers, upon the plant at Rome, N. Y., where lead is treated in vats in series of ten, which are there working. Thirty were put up, but have not been working on account of defects in the vats, defects causing the leakage of the electrolysis. But of the ten vats in series, I would say, they demonstrate practically all the principles that have been set forth in this paper of Mr. Slater, and in the paper which I shall bring before the Institute, either directly during the session, or in its printed publications.

Mr. KELLY:—I desire to ask for information. If I remember the experiment there is a certain amount of chemical corrosion going on all the time; it takes a certain amount of current to balance that chemical corrosion. Now, in arranging the vats in multiple series you reduce the density of the current. For instance taking four you have only one-half of the current you had before. The amount of increase of surface lessens the current. I think that proposition was right—that there was a chemical corrosion going on, and that you must ultimately reach a point where the density of the current would be reduced, and where it would balance the corrosive effect.

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A paper read by Mr. C. J. Kintner, before the American Institute of Electrical Engineers, at Philadelphia, October, 1884; with discussion thereon.

THE PATENT OFFICE: ITS RELATION TO INVENTORS AND ITS NEEDS.

I owe an apology to your honorable body for presuming to come before you with a paper of such hasty preparation as this has received; but it was only upon Saturday last that your Secretary advised me he would be pleased to have me prepare and present it.

It is needless to remark that I should not have dared attempt this preparation in so short a time, had I been forced to collect data from existing publications alone; and also, that it is only through my immediate connection with the Patent Office, through a series of years, as a member of its Examining Corps and as chief clerk, that I have been so familiarized with its workings, its needs and its relations to the public, as to enable me to give you briefly a history of its existing condition and all bearings thereon.

There is, I may safely say, no individual portion of that greatest of legal efforts, our National Constitution, which has been the foundation of such universal benefit, as section 1, article 8, which provides that all authors and discoverers shall have the right to the exclusive use of their productions and discoveries for limited periods of time; and upon this authority our forefathers, with, it would seem, a providential foresight in 1790, originated the first revised statutes concerning patents, thereby granting to inventors an exclusive right to the use of their inventions for limited periods of time, in consideration of a full and free disclosure thereof; this right to accrue to the public after the limited period has expired.

With very slight modifications the law of 1790 remains in existence, and our Government possesses to-day the best patent system in the world. As a result, inventive genius has been stimulated through this hope of reward, by the production of untold thousands of valuable inventions everywhere. I need not recount to you how we are transported from one metropolis to another at miraculous rates of speed; how our great harvests are gathered and carried to the four quarters of the globe at rates of speed that fifty years ago would have been seriously questioned—aye, absolutely denied; how our methods of communication have

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been improved, so that to-day contracts are made between London and San Francisco before the time of their actual date. In other words, that we actually ante-date time. Nor need I spend time in recounting the thousands of useful inventions, all covered by patents, that are daily crowding our homes, making life easier, existence happier, and adding in a thousand ways to our comfort, our intelligence and our mutual instruction; in short, elevating mankind. How many of the American people of to-day ever give this subject a thought, but rather take it as a matter of course. Yet I make bold to say that but for our patent system, executed under existing laws, we would to-day be in the condition of some of our sister European nations, struggling for a bare existence.

Indeed, our system has not only proved beneficial to us, but has stimulated the world at large, and to-day statistics show that nearly or quite one-half of the patents taken out in England, Germany, France, Italy and other countries, are by American inventors. It needs no assertion of mine to prove this; we have but to turn to the patent records of these Governments to ascertain this fact. I know it has been customary to attribute our individuality as a nation to the fact that we are peculiarly an energetic people, made up of the better elements of all classes of humanity and stimulated by the idea that this is a great free country, and that in each individual there lies the probability of the Presidency, to be looked at in the dim distance through the political horoscope; or of the untold wealth of a Rothschild to be hoped for from a financial standpoint, if perseverance and economy are prevailed in; but I make free to assert that this individuality of Americans is due to the labors of just two classes of persons, viz.: the Author and the Inventor, both of whom look to their success through the hope of protection of their respective industries for at least limited periods of time; the one by copyright, and the other by the patent system.

It is to the author that we owe our public schools, our culture, our tastes for arts and sciences, and all that goes to make life more elevated. It is to him, as a scientist, that we are indebted for research into the mysteries of life, inquiries as to how we may make life longer and free it from pain and sorrow; in short, he brings us nearer to the Creator.

It is to the inventor that we are indebted for all the comforts of life and the conveniences for interchanging thought and elevating our minds. He has given us the printing press, upon which

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to unfold, in expressible language, the best thoughts of our friend the scientist, and to prepare for both the youth and the older scholar food for thought. He has joined hands with the scientist, and unfolded to our gaze the mighty depths of space, revealing millions of unknown worlds, and myriads of unknown miniature creatures in the microscopic world. Where can we look about us and not see the work of his industry?

In the face of this progress, can there be found a person, who will seriously consider all those great advancements in the arts and sciences, and say that our patent system has not been almost wholly instrumental in it?

I take it that no argument is necessary upon such a question, as statistics will show. Where can be found to-day the inventor who labors for pure love of his productions, disconnected from a possible fortune in limited protection? Look over the list of great inventors, whose inventions have revolutionized the world, and show me a single instance of an inventor, since the commencement of the present century, who has not sought protection under our patent laws in some shape.

Let us now turn briefly to the question of the effect of patented inventions, and I will illustrate by a few examples how inventions open up new fields of labor, and furnish employment for thousands before otherwise employed, thus increasing the field of productive labor. Take the manufacture of cotton alone. Statistics show us, the Commissioner of Patents, Butterworth, advises me, that if all the men, women, and children of this country were constantly employed, night and day, they could not, by the old method of carding, prepare the cotton now raised in this country for the loom.

It is also known that were all the men, women, and children of New England employed constantly at pegging and sewing boots and shoes, they could not perform this work upon the material manufactured in and about the City of Boston.

These figures are startling, but have been gathered from an actual review of the work done.

So I might continue to show what patented inventions have done. How the telegraph, the telephone, the railroad, and thousands of other inventions have increased a thousand fold the field for labor; but this is only offered to show why our patent system should be fostered with the care it deserves.

Turning, now, to the Patent Office proper, I find it was formally established in 1836, when it became a part of the Interior De-

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partment, under the control of the Secretary of the Interior, and these relations have since been maintained, but little change occurring, save in the matter of increase of force.

The force, as originally constituted, did not embrace more than ten persons in all, the Commissioner of Patents included, and the annual issue of patents to, and including, 1840, was very meagre, indeed.

Since that time there has been, with two or three exceptions (notably during the civil war), a steady increase, until now the annual issuance is over 20,000, and the total number granted above 300,000; the total number of applications filed last year being over 40,000.

While this increase of patents has occurred, the increase of force and conveniences of accommodation in the matter of the examination of applications and issuance of patents have fallen sadly in arrears.

The present force of the Patent Office numbers, in all, about 550, and is apportioned approximately as follows:

Assignment Div.	100
Draughtsman Div.	125
Examining Corps	150
Issue and Gazette	75
Chief Clerk's Div.	100
	550

I will recount briefly the duties of each of these divisions, and their existing conditions.

1st. The assignment division is employed in recording all assignments of patents and records appertaining to patents, and is, briefly, to patent property, what your well-known office of records and deeds is to real property—an office of record.

Besides this, the force is employed in furnishing copies of all papers ordered for suits at law, copies of files and contents, and generally of the papers of the office, when called for in court and other proceedings, whether under seal or otherwise. The requirements upon this division are enormous, as you may well imagine, when you come to consider the enormous amount of litigation growing out of over 300,000 patents, more than 200,000 of which are still in legal force.

The force is not at all sufficient for the needs of the office, and

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the division is months behind in recording deeds and furnishing copy. A delay caused by this arrangement may, any day, embarrass interested parties thousands of dollars.

2d. The draughtsman division. This division has charge of all matters appertaining to the drawings of patents, both before and after issue; collects the drawings, stores and classifies the patented drawings and specifications as the patents issue, so that when copies are ordered they may be had at short notice; supervises the photo-lithographing of drawings, and keeps the lists complete by reproduction as they expire; classifies the photographs for examiner's use, and also for the use of attorneys and others making preliminary searches in the office, as to novelty.

It also has charge of the matter of mounting foreign drawings for the use of examiners in their various divisions; pasting together the specifications and drawings of patented files, &c. The work of this division is sadly in arrears, owing to the increased issues of patents for the past two years.

3d. The issue and Gazette division is employed, as its name implies, upon the matter of preparing patents for issue, and to this end the work embraces proof-reading, indexing, numbering, preparing the patents, and editing the *Official Gazette*—a weekly publication, of about 100 pages, quarto, devoted to keeping a correctly classified record of all patents as they issue, giving names of inventors in each case, date and number of patent, title of invention, claims, &c., &c.; and in general containing all matter concerning the general conduct of office business—such as Commissioners and Court decisions, general orders appertaining to official changes of classification, &c.

The work of this division is up, and must be kept up, to the exclusion of other work, for the patents must issue when they take their date and number, and the weekly *Gazette*, like any periodical, must not fail to come forth on time. However, there is need of more force here, if it could be had, and a minimum force is employed, so as not to cripple other divisions too badly.

4th. Chief clerk's division embraces all the force immediately under the supervision of the chief clerk of the office, and is employed as follows:

1st. Financial division, where all moneys paid into the office are received.

2d. The mail division, where all mail matter is received, regulated, and properly distributed, and all outgoing mail properly classified and forwarded.

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3d. The application division, where the applications for patents, with all amendments and papers appertaining thereto, are received, numbered, entered in registers, and forwarded to their proper examining divisions.

4th. The scientific library, where all printed publications and foreign patents are received, catalogued, and shelved, for use of the examining corps and inventors.

5th. The interference and appeals division, wherein are kept all records of contested cases and appeals, ex parte or otherwise.

6th. The model department, where are stored all patented models, which are carefully classified and catalogued, for future reference and use.

The chief clerk also has charge of all correspondence, wherein inquiries of a general nature are made, and is the confidential adviser of the Commissioner, and has general supervision of the whole office force, looking after the individual wants of various official divisions, and supplying, through the proper channels, all necessary articles for the conduct of business, such as furniture, fuel, stationery, &c. This force is insufficient, but, like the issue and Gazette division, is of vital importance, inasmuch as it has to do with the financial portion of the machinery, and it is important that the correspondence and immediate demands upon the office be attended to promptly, so it draws from the other divisions to keep the work within limits.

The last, but most important, division, touching the validity of patents, is the examining corps.

The official classification of patentable subject matter is divided into 26 divisions, representing 25 branches of the arts and sciences, the 26th division being the Court of Interference, or contested cases.

These 25 divisions have each their Supervising Officer, known as the Examiner in Charge, and under his supervision are four assistants, grading from 1st to 4th assistant inclusive, with salaries ranging from $1,800 to $1,200 per annum.

The Principal Examiner is supposed to be well skilled in the art he has chosen to supervise, and to have a thorough knowledge of patent law and practice; and his assistants are required to be proportionately well skilled in all such matters, and are, I think I may safely say upon the whole, as efficient a body of men as could be desired. It is the duty of these men to pass upon the applications which come before them as to novelty and utility. They are

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the judges who, in nearly ninety-nine cases out of a hundred, pass finally upon the applications coming before the office. In other words, they grant the patents. They should be well posted in matters of the arts, at least to such an extent that they know whether a device is operative or whether it is novel in view of what has been before done in the same art, reference being had to prior patents—domestic and foreign—and to printed publications and public use.

To obtain men of this class, it has been the custom for ten years or more, to hold competitive examinations for the lowest grade and for promotion in the several grades upon technical matters, and to this end the Patent Office claims to be the father of civil service reform. The class of men appointed under such a course has been found to meet the requirements effectually, and so far as efficiency is concerned, I think, with few exceptions, there can be no objection to the existing force.

The only matters I want to especially urge upon your honorable body are—1st, the need of greater force generally for the office; 2d, more room; and 3d, a mechanical and chemical laboratory or workshop for the Examining Corps.

It is needless for me to say that for the past ten years Commissioners of Patents have, without exception in their annual reports, urged upon Congress the necessity of the first two of these questions. But as earnest as have been their individual efforts in this direction, I must say that with due regard to all of them, none have done more or appreciated more kindly the wants of the office than the present commissioner, the Honorable Benjamin Butterworth. Through his efforts the force has been increased during the past year about 10 per cent., and additional space to the amount of twenty rooms added, by forcing the Indian office out of the building.

First, then, as to the question of force. If the increase of force of the Patent Office had kept pace with the rapid increase of the patent business, and with its requirements necessitated by the great business interests of the country, resulting from patented profits and litigation thereon, it would, instead of numbering 550 employees, to-day number over 1000.

Take the Patent Office reports from 1850 to July 1st, 1884, together with the immense interests which have accrued in that interim and compare statistically if you will the forces employed at those times and the emergencies in the nature of the case, and

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you will ascertain that my figures are rather under than over the estimate.

As a result of the insufficient force now available and the cramped quarters occupied by the Examining Corps, many of the divisions are months behind. In harvesters, one of the most important classes of inventions, they are fourteen months in arrears; in textile fabrics over eight months; in my own class, in which you are especially interested, over five months; so that were you to file an application to-day it would be, in all probability, five months before I could even take it up for examination.

Now, gentlemen, this should not be. You, the inventors in the electrical art, have a right to demand that your interests shall be more promptly attended to than this; and you ask me why the delay? It is simply because there is and has been for the past ten years an impetus in inventive genius such as the world never before witnessed. It is not spasmodic, it is not to-day, or to-morrow, or next year that this is to cease, for the indications are that this great people are on the very verge of an onward wave of progress, such as was never before known to the civilized world, and the wonders of to-day are only noted to-day to be eclipsed to-morrow by the culmination of something which is the result of Yankee ingenuity, only more wonderful than that which preceded it; so that we begin to think that perhaps after all there is a probability of all things being possible even within the brain of that humble creature, man.

In the prospect of this great era of inventive age—not only in its prospect but in its reality, there is a future more prolific than all the past and a future of realization without doubt. And the necessities of the case demand an absolute increase of force in all the divisions of the Patent Office, for the reason that as the various arts advance more exhaustive knowledge of them must be had.

Patents and publications must be briefed and reduced to manageable limits, so that an examiner can make his searches more expeditiously and give to you patents which are what they seem to be, valid contracts, both as to novelty and utility.

In this connection, much has been said about our system as compared with the English, where a patent is granted on every application presented, without search as to novelty. If I had time I would show you the fallacy of attempting to prove that the English system is cheaper in the end, and would show you how our

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system stimulates invention by causing inventors to study more closely an art to improve upon existing patented devices. But at some future time I may present a paper on the comparative systems and will treat of the matter fully there. Suffice it to say our system is infinitely cheaper in the end, and undoubtedly so if we make it as efficient as we should by providing the necessary qualified force, so as to make searches as to novelty exhaustive, as was the intent of the law.

2d. As to the question of room. I seriously wonder how many of the visitors to our beautiful National Capitol are aware of the fact that the great and magnificent building known as the Patent Office proper, and illustrated in our public libraries and wherever shown as the Patent Office, is in fact occupied only in a small part by the Patent Office.

Built by the money of the inventor, wrung from him with the idea that he is to have for his preliminary fee of $15 (little enough it is true, but nevertheless paid for a special purpose), that he is to have, I say, an exhaustive search; that his patent is to be a valid contract as to novelty, so far as human search can determine; that with the surplus of the money thus taken from the inventors this building has been built, and commodious rooms and halls, to be occupied, not by the Patent Office and an efficient corps of examiners, to do that for which the Government contracts, but by the Interior Department, consisting of the Land Office, the Railroad Office and the Indian Office, a portion of the Examining Corps being crowded down, as Senator Platt so truly in his speech before the Senate said, "into the coal vaults and cellars of the building; part of the model hall having been captured and turned into quarters for the Land Office."

Such are the facts; and to-day the Electrical Division is occupying two small rooms on the ground floor under which there is no cellar, and the walls are so damp and quarters so crowded as to cause much sickness. I desire to call especial attention to Senator Platt's speech, upon his bill, for making the Patent Office a separate department, under control of the Commissioner of Patents. It can be had by addressing the Clerk of the Senate.

The Government should, in duty to its trust with inventors, see to it that the Patent Office has especial control of the whole building, and has such facilities as the necessities of the case demand.

There are other examiners who are in much worse rooms than it is my misfortune to be, and are occupying those rooms which some years ago were used as coal cellars.

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The 3d question I wish to present to you is the necessity for a thoroughly organized laboratory and workshop in the Patent Office. This is a feature to which I have called attention more than once at the office, and during my imcumbency as Chief Clerk in 1883 I was instrumental in obtaining a meagre appropriation of $200 towards establishing a chemical laboratory. Such was the nucleus of the existing laboratory, the total value of all the material to-day being less than $500.

Now, gentlemen, what do you think of a bureau of scientific experts upon mechanical, electrical, and chemical technics, without any mechanical workshop, without any electrical apparatus, and with a laboratory having a total valuation of less than $500.

Here am I, the electrical expert of the United States Patent Office, as head of the electrical division, expected to pass upon your inventions, coming, as they do, from a society of highly educated, practical, experimental electricians, as to their utility, their operativeness, and their results, without any of the modern appliances of experimental apparatus.

What apparatus have I, do you say? Well, let us recount the complete stock.

1st. Ten cells of Bunsen's battery, presented to the office by Chas. E. Buell.

2d. One small hand dynamo, presented to the office by Chas. J. Van Depoele.

3d. Two small galvanometers, of old pattern, without any attachments, other than needle circular gradations and binding posts; both presents to the office.

You, doubtless, would like to know how I pass upon the efficiency of certain devices, such as instruments for overcoming induction, testing telephones, the efficiency of batteries, &c. In reply, I simply add, I don't pass at all, but pass the case to issue, if it is not too flagrant a violation of well established principles, and not contrary to well accepted theories, a policy, you must admit, not the most wise in these days of advancement, when old theories crumble before experimental facts.

Now, gentlemen, this should not be. The Patent Office should, as the head centre of the records of inventive genius, at least do what it pretends to do, grant patents for actual working apparatus in every instance, and an examiner should be morally certain that a device works as it is claimed to work, that a process evolved brings about the result specified, or that a composition of

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matter does all that is claimed for it. No alleged inventor should be allowed, under the guise of law, to impose upon an unsuspecting public, simply because the government has seen fit to grant him unwittingly a fraudulent patent.

To this end, I hold it is your duty, as inventors and as good citizens, to see to it that the Patent Office is provided with the material, both in the nature of a sufficient force and of experimental apparatus, to the end of the public good.

The question naturally follows, how shall we accomplish this end.

Gentlemen, it lies with you, the inventors, and with the corporations and business interests using patented inventions, and not with the employees of the office, to bring about the results I ask, and I will point out, as briefly as possible, how it may be accomplished.

It may not be generally known to you, but it is true, that there lies to the credit of the inventors of this country, and of such other countries as have obtained patents of the United States, nearly $2,000,000, over and above all actual expenses incurred in granting those patents. Money wrongfully extorted, and now lying dormant in the Treasury. Several attempts have been made of late in Congress to turn this fund over to educational purposes, but, so far, without avail.

There goes annually into the same deposit over $200,000 surplus, above the annual expenditures of the office.

Now, I submit, that this money is the property of the inventor, levied for a special purpose, and cannot, under the Constitution, be misappropriated. In other words, you are, as a class of people, being virtually robbed every year of $200,000.

What, then, is your duty?

It is plain enough.

You must go before Congress and express, in language unmistakable, your desires in this direction. You must buttonhole your individual members of Congress, and give them to understand plainly what you want in this direction. I tell you, gentlemen, there is nothing works upon a member of Congress like a pressure from his immediate constituents.

The average congressman is a selfish creature, ever watchful of the public pulse, particularly when that pulse beats feverish in his own immediate district.

It is then your duty to go individually and collectively to your

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representatives and place this issue before them. Obtain copies of the Platt bill and speech, and read it. Urge the necessity of its passage, and put the Patent Office on a footing such as the advanced position of this great free government demands.

Let us have an increased force of examiners, at salaries justified by the position they command.

Let us have the whole of the Patent Office building. It is yours to command, and purchased with your funds.

Let us have all the facilities we demand, and when this occurs we will be provided with expert examiners equal to the emergency, who when they become proficient and useful in their calling shall not be tempted to more lucrative positions outside the Patent Office, as is now daily the case. In this connection I desire to call attention to the fact that one of my assistants has resigned since your last meeting, and another will go out within a month to fill a position at an advance of salary.

I shall have to educate new men to fill their places, only to lose them when they become proficient.

Doubtless you ask yourselves why I display so much interest in the matter of increased salaries. Is this increase of salary sought through selfish motives, is this increase of room for mere self comfort?

No, gentlemen, I beg to advise you that I can at any day leave the Patent Office, at an increased compensation above my present salary, and have been asked within the year to accept a partnership in a firm practicing patent law, where I am guaranteed over $3,000 per annum.

I make these requests in the interests of the office, and add, by way of conclusion, that when I do seek a livelihood elsewhere it will probably be in the patent business; and desirous of speedy action and accurate work on the part of my successor, I think the measures I have to-day advocated will be also heartily indorsed by every practitioner who comes before the office. And in conclusion, gentlemen, let me hope you will not permit this matter to drop here. You may rest assured you will find in the present Commissioner, Hon. Benjamin Butterworth, a hearty co-laborer, who is ever ready to aid the inventor and is alive to the interests of the public good, and appreciates to-day more than any other public man that the position we occupy as a nation is due more to our inventive genius, stimulated by the best patent system the world ever knew, than to any other cause.

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DISCUSSION.

The CHAIRMAN (Mr. W. D. SARGENT):—Gentlemen, Mr. Kintner's most interesting paper is before you. Are there any remarks upon the subject?

Mr. C. J. KINTNER:—I would be very much pleased to answer any inquiries that may be made upon the subject.

The CHAIRMAN:—Can we hear from Mr. Jannus on that subject?

Mr. JANNUS:—I fully indorse all Mr. Kintner has said. The thing we suffer most from is that the average congressman when he comes to Washington feels that he has a great field before him, and instead of really coming down to the consideration of the few much needed changes in the Patent Laws, getting letters from his constituents concerning patent matters, he uses his time trying to bulldose the Commissioner into ordering immediate action on his particular case. Now if his case is made special it disposes of all the interest he has in the matter of patents. The men that bother him are satisfied, his case is terminated, and the rest may wait. This is simply inexcusable, and I am glad to say, less successful now than formerly.

You can hardly appreciate the position of a Washington attorney, but if any of you had forty or fifty cases pending in Mr. Kintner's division and were receiving letters every day, and people were coming into the office every day and inquiring why has not my case been acted upon, you would be nearly worried to death. You go to an examiner and ask about a case. He will refer to it; it is among fifty packages of papers, perhaps half way down; you inquire when it will be reached, he looks ruefully at the pile before him and replies "Well, about three months or so," and that's the best you can do. Now this is the condition of affairs, as Mr. Kintner has shown, in his division, and his is not the worst.

I remember about two years ago a harvester case was talked of in connection with myself as attorney. A week ago I carried the model of that case to the Patent Office. The case had been nearly two years before the Patent Office before it was taken up, and then the first thing the examiner did was to call for a model. That is simply an outrage. Mr. Kintner has very well said that every man, woman and child in the wheat growing districts, if they worked all the time, night and day, would be absolutely unable to

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harvest one-tenth of the crop grown. There is no question as to the value of these inventions! There is no question as to the progress that has been made in this business, and the instance I have named is an example. That division, covering mechanisms as important as any other, is nearly two years behind-hand, and the matter is getting worse and worse every day. There does not seem to be any chance for relief.

Now, as to the so-called Patent Office, it is a misnomer. It is a Land Office with a patent office attachment. I go into one examiner's room, finish my business and want to see the head of another division. I have to go all around the Patent Office building, which occupies two entire squares, nearly a quarter of a mile, to get to the next examiner's room, just because there happened to be a room there which nobody else wanted, so it was used for this purpose.

I only offer these remarks in corroboration of what Mr. Kintner has said, and to call your attention to the fact that making a case special is not the way to help what I believe might so easily be made the best patent system known.

Mr. KINTNER:—Mr. Jannus' remarks bring one matter very forcibly before my mind, and that is the manner in which the Commissioner, Mr. Butterworth, has been enabled to increase our force ten per cent.; and when I say that the increase of ten per cent. has been made during the time when the Presidential contest was going on, it is something remarkable in the history of the office. It is only by reason of the fact that General Butterworth has positively forbidden the making of any case special. When members of Congress come to ask him to make a certain case special, the reply is, "Gentlemen, I cannot do it." He simply says in so many words, "I would not do it for my grandfather." I have seen a whole delegation from Congress come before the Hon. Commissioner of Patents, both Senators and Representatives, to urge, with all the power they could make use of, that the cases of their constituents be made special; and I have yet to find that the Hon. Commissioner has once changed his opinion in that respect. And it is largely upon this basis that he has been enabled to force upon Congress the idea that we must have an increased force in the Patent Office. You can very readily see what has been the result from the Commissioner's refusal to make any case special.

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General Butterworth has had the manliness to come out and say, "Gentlemen, I will not make a case special for any one of you." There is only one way in which a case can be made special, and that is under the rules where the head of a department shall specify that the invention for which the applicant is calling for a patent is of such general and public welfare to the Government that it will be deemed necessary to make it special, and to take it up at once.

In reference to this, I wish to add, that unscrupulous inventors have taken advantage of this fact, to go before the heads of the various departments to urge their cases, I mean before the secretaries. In this way, in some instances, cases have been made special that were not meritorious. I know that has been done in my class, and I have called the attention of the Commissioner to the matter, and he has used his powers, so far as possible, to prevent the violation of this rule.

You see the rule is a necessary one. In time of war it may become necessary to patent some particular apparatus of warfare, and patent it speedily; it may be necessary for the Secretary of War to take advantage of this rule, and he may make a request to that effect. Unscrupulous inventors have sought to evade the rule, and in this direction, I am thankful to say, that even there, there has been a stop put to it, and we now shall soon have the Patent Office on the footing that we desire. Within the past six months we have been able to turn the Indian Office from the Patent Office building, and have gained twenty rooms; and the Commissioner has made attempts in other directions. I hope ultimately the Patent Office will occupy the whole building, and that we shall be placed upon a basis such as the Patent Office deserves.

I might have said much more in this paper, but it seemed to me very long as it was. I have only given you the general outline of the manner of conducting business in the Patent Office. It seems to me that you, as inventors, and you as a particular class of inventors, who have necessarily much power before Congress, can do much in this direction. I urge you, therefore, again, strenuously, to do what you can to aid us.

Just one word more as to the members of the examiner's corps now in the Patent Office. I want to explain more fully the condition under which we are placed by having examiners leave the office, particularly in my class. During the time I have been connected with the Patent Office, since the year 1880, the entire

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personnel of the Electrical division has changed. I went in as second assistant in 1880, and there is not one of the force at that time there who is now in the division, except myself. From the examining corps, I was promoted to the position of Chief Clerk, afterwards to Examiner in charge of the Electrical division, and in that time the entire personnel of the division has changed three times. What is the result?

I take it that I need not go into the question of showing to you of what use is the process of examination as to novelty or in what that consists. It simply amounts briefly to taking up each application in its order, and ascertaining whether the invention is novel or not. To do this it is necessary that each examiner should be thoroughly familiar with his particular art. Take, for instance, the class of dynamo machines. This is a class now involving between 500 and 1,000 patents in the American list alone, and it involves I should say 1,000 English patents. It involves in the matter of publication no one knows how much.

Now the most important portion of the electric art has been developed within the last ten years. It is not necessary for me to tell you this, it is well known to all of you. Within that time we have not one line of briefs of English patents, and we have not one line of briefs of American patents; and we have not one line of briefs of the publications of the day; but the whole state of the art is carried in the head of the assistant examiner who is under my charge, and in my own head too.

We all of us know that it is not safe to trust to memory upon a question of searches in patentable matters. The assistant in charge is liable to leave me at any time, and, when he goes, he carries away everything he knows. I am under the necessity then of putting in a new man, who must learn everything afresh, and the result is invalid patents are issued—patents very detrimental to other inventors. I have not anything more to remark upon the question. I think you fully appreciate the condition of the office, and will do what you can towards putting it upon a sound footing.

Prof. EDWIN J. HOUSTON:—I think it is a very fortunate circumstance that Mr. Kintner has brought this matter before our attention. It is certainly an important matter, since it touches the future patents in our country, and I am glad that a person officially connected with the Patent Office, as Mr. Kintner is, expressed himself so fully in regard to this matter.

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We all know the great difference which exists to-day between the English Patent Laws and our own. In England, I believe, they have reached that state, in which a patent is issued as a matter of course. The result of this is, that the patent papers issued by the English Government are practically worthless until a case is tried by the courts.

Mr. KINTNER:—It is so, as a matter of course, if they don't know otherwise. If they happen to know it is patented in the United States, they will not grant a patent; or if there is anything against it.

Mr. HOUSTON:—They do not make a search upon which the value of the patent depends. Now, it seems to me, that we are fast approaching the time when either we must make more careful searches or must practically abandon our patent system, and give a patent as a matter of course. There can be no doubt as to the advantage our system has over the English. It seems to me to assure the value of all patents that are granted, it is absolutely necessary that there should be placed in the hands of the examiners and patent officials such a laboratory as Mr. Kintner has suggested. If it is necessary for an inventor to have all the modern scientific appliances at his disposal to make inventions, it is equally necessary for examiners to have at their disposal such appliances as will permit them to see whether the things claimed are novel, and whether certain combinations are workable or not. I do hope some action will be taken in this direction. It will do more to advance the interests of inventors than probably any other thing we can do.

Mr. N. S. KEITH:—Mr. Chairman, I merely suggest the remedy; and that is that every one of us members who knows any congressman, or who knows any friends who know any congressman, endeavor to influence that congressman in favor of the Patent Office, and in favor of the patentee.

There is what is called a strong granger influence adverse to patents. Men who are so short sighted as to think that the duty that they are paying upon reapers, mowers, binders and so forth is a mere duty from which they do not gain any advantage and from which they can gain no advantage. But if this subject is brought to them properly, to the effect that if they had no binders, no reapers and mowers, their crops would cost them far more, and that they would never be able to gather them, they would understand the matter better. The farmer has undoubtedly suffered

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somewhat because of wrongfully purchasing, innocently enough, apparatus for which he has had to pay again thereafter; but it argues nothing against the patent system, and the protection which it gives the inventor.

Mr. MAYNARD:—I would like to inquire whether there is any necessity for a legal requirement that cases should be acted upon in the order in which they are presented. As the practice now is it depends upon the judgment or whim of anybody who happens to hold the office of Commissioner of Patents. I understand that applications are sometimes marked "special in the order of specials." There seems to be an order of special and regular papers.

Mr. KINTNER:—I will explain. The law indicates the order in which applications should be taken up. Also the rule of practice indicates the order in which applications are taken up. They are taken up as I said upon the authority of a Secretary of one of the departments for the reason above given. They are taken up also when an application has been previously patented abroad for a very obvious reason that the American patent, which is limited by the life of foreign patents, has its life already begun. You catch the idea; it is that with the patent previously taken out abroad its term is shorter than seventeen years. The American patent is limited by the foreign patent, therefore its life has begun to run and it must be taken up at once. If it is a re-issue application for a patent already granted, where the patentee is seeking to protect his claims, or for obvious reasons is seeking for a change in his patent, or in some other way to correct it, it must be taken up because the life of the patent is already running.

As to the question of order of specials, that refers to the papers in the office and has no reference to an application. Sometimes papers are filed and there is an order calling for copies. Copies of important papers are needed to be used in court during the progress of a suit, or before the Supreme Court, or before other courts where it is absolutely necessary that the copies should be before that court on a certain day. Cases of that nature occur, but they have nothing to do with applications. I am speaking merely of copies of papers; cases of that nature are sometimes made special by the Commissioner, and they are made special, in the order of specials. These specials take the preference over any other for obvious reasons, but that has nothing whatever to do with the question of the issuance of patents. It is merely where

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such papers are to be used in court or otherwise, where the copies are required.

Mr. MAYNARD:—I would like to ask one more question. There are some neighbors of Mr. Jannus who claim that they have special facilities for obtaining patents. How is this?

Mr. JANNUS:—You will see something of this kind advertised every day. Every conceivable inducement is made to get an inventor's business, and the sole end and aim of these persons is to devise, or imagine, or get some one to suggest to them, some scheme that is plausible and they will advertise it. All they want is plausibility, and they work on that to an extraordinary extent. Really their circulars are comical. A fair idea of the official estimate of their responsibility may be obtained from Patent Office rule 17, which says in substance that it will be *unsafe to trust* those who pretend to have any better facilities for obtaining patents than diligence and skill in their profession.

I will just relate a little experience of mine recently, and you will see what to think of special facilities.

A firm in New York filed a case belonging to a class that is considerably behind-hand. Of course it took some time to be reached. When it was reached references were given, and they did not leave much of the case. It was not an electrical case by the way. Well, in order to bring out what was left of the case more fully, a new drawing was made illustrating the part, the specification was revised and the claims restricted to that particular feature. The examiner made a further re-search and then cited references which did not leave much of that. The result being that after fighting over the case for some time they got a final rejection. The attorney thought there was something novel in the case, and that it had been fully brought forth, and therefor advised an appeal to the Board. Now then the applicants in this case thought they would try some of the special-facility men. So they revoked the power of attorney of the original solicitor and placed the matter in the hands of a special-facility man. This *expert* met the same fate as his predecessor and the case remained finally rejected; so what did he do? He re-prepared the application under a different title, copied the drawing identically, had another man swear to the papers, and filed the case in the Patent Office, as I say, under another title, so it went to another examiner.

Now there are one or two regular moss-backs among the examiners, men who don't make any examination to amount to

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anything. If they think the thing is new, they sign the papers. Their work is always up. They don't have any trouble and they don't care whether the thing is novel or not. They are all right as to their cases, they know.

Mr. KINTNER :—That is the English system.

Mr. JANNUS :—It is an exemplification of it. This case went to one of the very worst of these men and he took it up. He attended to it himself to make it a still better job ; he looked at the outside of the file, didn't think he had anything like it, passed it out, and in six days from the time it was filed the attorney had the patent allowance.

That attorney crowed over the others and said, " I am the man who can get you a patent. I have special facilities."

Now, gentlemen, in the first place somebody had been guilty of perjury, somebody else had been guilty of a most outrageous trick, and as matter of fact, the references on which the original application stood rejected came out of the second examiner's class, I know of these facts, and that the record upon which the original application as rejected came out of the second examiner's class. Last but not least it may be well to add that a patent granted as above is simply a snare and a delusion, and about as worthless as a second-hand poultice, for the references applicable to this (or any) case are always accessible to any one desiring to ascertain the *value* of a patent.

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APPENDIX.

American Institute of Electrical Engineers.

RULES.

I.

OBJECTS.

THE objects of the AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS are to promote the Arts and Sciences connected with the production and utilization of electricity, and the welfare of those employed in these industries; by means of meeting for social intercourse, the reading and discussion of professional papers, and the circulation, by means of publications among its members and associates, of the information thus obtained.

II.

MEMBERSHIP.

The Institute shall consist of Members, Honorary Members, and Associates. Members and Honorary Members shall be professional electrical engineers and electricians. Associates shall include persons practically and officially engaged in electrical enterprises, and all suitable persons desirous of being connected with the Institute, and duly elected as hereinafter provided. Each person desirous of becoming a member or associate shall be proposed by at least three members or associates, canvassed by the Council, and elected by a majority of the members and associates as expressed by letter-ballot to a regular meeting of the Council, and shall become a member or associate on the payment of his entrance fees and dues for the first year. Each person proposed as an honorary member shall be recommended by at least ten members or associates, and be elected by the Council; *Provided*, that the number of honorary members shall not exceed twenty. The Council may at any time change the classification of a person elected as associate, so as to make him a member, or *vice versa*. All members and associates shall be equally en-

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titled to the privileges of membership; *Provided*, that honorary members shall not be entitled to vote or to be members of the Council.

Any member or associate may be stricken from the list by the vote of three-fourths of the members of the Council, due notice having been mailed in writing by the Secretary to the said member or associate.

III.

DUES.

The entrance fee shall be five dollars for each person. The dues of members and associates shall be ten dollars per annum, payable in advance at the annual meeting. Honorary members shall not be liable to fees and dues. Any member or associate may become, by the payment of one hundred dollars at any one time a life member or associate, and shall not be liable thereafter to annual dues. The dues of members residing in foreign countries—beyond the seas—shall be five dollars per year, but such members shall have no vote for election of members. Any member or associate in arrears may, at the discretion of the Council, be deprived of the receipt of publications, or stricken from the list of members when in arrears for one year; *Provided*, that he may be restored to membership by the Council on payment of all arrears, or by re-election after an interval of three years.

IV.

OFFICERS.

The affairs of the Institute shall be managed by a Council, consisting of a President, six Vice-Presidents, twelve Managers, a Secretary and a Treasurer, who shall be elected from among the members and associates of the Institute, at the annual meetings, to hold office as follows:

The President, the Secretary, and the Treasurer for one year (and no person shall be eligible for immediate re-election as President who shall have held that office subsequent to the adoption of these rules, for two consecutive years), the Vice-Presidents for two years, and the Managers for three years; and no Vice-President or Manager shall be eligible for immediate re-election to the same office at the expiration of the term for which he was elected. At each annual meeting a President, three Vice Presidents, four

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Managers, a Secretary, and a Treasurer shall be elected, and the term of office shall continue until the adjournment of the meeting at which their successors are elected.

At the first meeting for the election of officers, a President, three Vice-Presidents, to serve one year; three Vice-Presidents, to serve two years; four Managers, to serve one year; four Managers, to serve two years; four Managers, to serve three years; a Treasurer to serve one year; and a Secretary, to serve one year, shall be elected.

The duties of all officers shall be such as usually pertain to their offices, or may be delegated to them by the Council or the Institute; and the Council may in its direction require bonds to be given by the Treasurer. At each annual meeting the Council shall make a report of proceedings to the Institute, together with a financial statement.

Vacancies in the Council may occur by death or resignation; or the Council may by a vote of the majority of all its members, declare the place of any officer vacant, on his failure for one year, from inability or otherwise, to attend the Council meetings or to perform the duties of his office. All vacancies shall be filled by the appointment of the Council, and any person so appointed shall hold office for the remainder of the term for which his predecessor was elected or appointed; *Provided*, that the said appointment shall not render him ineligible at the next annual meeting.

Five members of the Council shall constitute a quorum; but the Council may appoint an Executive Committee, or business may be transacted at a regularly called meeting of the Council, at which less than a quorum is present, subject to the approval of a majority of the Council, subsequently given in writing to the Secretary, and recorded by him with the minutes.

V.

ELECTIONS.

The annual election shall be conducted as follows: Nominations may be sent in writing to the Secretary, accompanied with the names of the proposers, at any time not less than thirty days before the annual meeting; and the Secretary shall, not less than two weeks before the said meeting, mail to every member or associate (except honorary members), a list of all the nominations for each office so received, stamped with the seal of the Institute, to-

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gether with a copy of this rule, and the names of the persons ineligible for election to each office. And each member or associate, qualified to vote, may vote, either by striking from or adding to the names of the said list, leaving names not exceeding in number the officers to be elected, or by preparing a new list, signing said altered or prepared ballot with his name, and either mailing it to the Secretary or presenting it in person at the annual meeting; *Provided*, that no member or associate in arrears since the last annual meeting shall be allowed to vote until the said arrears shall have been paid. The ballots shall be received and examined by three Scrutineers, appointed at the annual meeting by the presiding officer; and the persons who shall have received the greatest number of votes for the several offices shall be declared elected, and the Scrutineers shall so report to the presiding officer. The ballots shall be destroyed, and a list of the elected officers, certified by the Scrutineers, shall be preserved by the Secretary.

VI.

MEETINGS.

The annual meeting of the Institute shall take place on the third Tuesday of May, at which a report of the proceedings of the Institute, and an abstract of the accounts shall be furnished by the Council. Two other regular meetings of the Institute shall be held in each year, at such times and places as the Council shall select, and notice of all meetings shall be given by mail, or otherwise, to all members and associates, at least twenty days in advance. Special meetings may be called whenever the Council sees fit; and the Secretary shall call a special meeting on a requisition signed by fifteen or more members. The notices for special meetings shall state the business to be transacted, and no other shall be entertained.

Every question which shall come before any meeting of the Institute, shall be decided, unless otherwise provided by these Rules, by the votes of a majority of the members then present. Any member or associate may introduce a stranger to any meeting; but the latter shall not take part in the proceedings without the consent of the meeting.

VII.

PAPERS.

The Council shall have power to decide on the propriety of communicating to the Institute any papers which may be re-

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ceived, and they shall be at liberty, when they think it desirable, to direct that any paper read before the Institute, shall be printed in the Transactions. Intimation, when practicable, shall be given, at each general meeting, of the subject of the paper or papers to be read, and of the questions for discussion at the next meeting. The reading of papers shall not be delayed beyond such hour as the presiding officer shall think proper; and the election of members or other business may be adjourned by the presiding officer, to permit the reading and discussion of papers.

The copyright of all papers communicated to, and accepted by, the Institute, shall be vested in it, unless otherwise agreed between the Council and the author. The author of each paper read before the Institute shall be entitled to twelve copies, if printed, for his own use, and shall have the right to order any number of copies at the cost of paper and printing, provided said copies are not intended for sale. The Institute is not, as a body, responsible for the statement of facts or opinion advanced in papers or discussions at its meetings, and it is understood that papers and discussions should not include matters relating to politics or purely to trade.

VIII.

AMENDMENTS.

These Rules may be amended at any regular meeting by a two-third vote of the members present, provided that written notice of the proposed amendment shall have been given at a previous meeting.

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AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

Annual Meeting.

May 19, 1885.

The meeting was called to order at 8 P. M. on May 19, at the rooms of the American Society of Civil Engineers, New York city, by Mr. Rowland R. Hazard.

The Chair appointed as scrutineers Messrs. Frankland Jannus, Joseph Wetzler and Sidney F. Shelbourne, to canvass the ballots for officers.

The Chairman: I might say, while the balloting is progressing, that Mr. Stephen D. Field has sent in his resignation as a member of the Council, not of the Association, and it is proper that we should take some action upon that, because if some other name is to be substituted for his, it might be voted for now while the others are being counted.

Mr. F. L. Pope nominated as Manager in place of Mr. Stephen D. Field, Mr. William D. Sargent.

Mr. Martin seconded the nomination and it was carried.

The Secretary then prepared ballots and distributed them among the members.

The Secretary then read his report.

THE SECRETARY'S REPORT.

It is provided by our sixth rule that a report of the proceedings of the Institute shall be furnished at the annual meeting. As Acting Secretary, I am glad, therefore, in fulfilling the requirements of the rule, to lay before the members and associates at our first annual meeting, statistics of the most encouraging character.

Under the circumstances familiar to most of the members present, this society came into existence just a year ago. It has already 279 members and associates, in all parts of the country. From the numerous inquiries addressed to the Secretary and Council, as to the objects of the Institute, the steady increase in the number of applications for admission, and the work done durin the past twelve months, it is evident that the Institute will soon compare in strength and usefulness with the older engineering societies, upon which it has been modeled.

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As will appear more fully from the Treasurer's report, the sum of $2,315 has been raised during the year, and the sum of $1,454.68 expended, leaving a balance of $860.32.

Soon after the formation of the society, the Directors of the International Electrical Exhibition held at Philadelphia, under the auspices of the Franklin Institute, tendered to it the free use of rooms in the exhibition building as long as it remained open. The offer was accepted by the Council, and the Secretary was authorized to make the necessary preparations and to be present during the Exhibition as the representative of the Institute. The rooms were accordingly prepared, and were opened to members on September 2d, remaining open until October 11th. They were visited by a great many members and by several foreign electricians. On Oct. 7th and 8th a meeting was held, partly at the Continental Hotel and partly at the Exhibition rooms, when papers were read and discussed. On the invitation of the Franklin Institute, the Exhibition was also inspected by the members in a body.

The first volume of the Transactions of the Institute was published in March of this year. It contains a historical preface detailing the steps taken to organize the Institute; the rules and regulations; and the eleven papers read at the Philadelphia meeting. As the Institute is still so young, it may not be out of place to note that the volume has been given a most cordial welcome at home and abroad, and has been the subject of several complimentary reviews in the scientific press. Of the one thousand copies printed, about three hundred have been distributed.

The Institute is without a permanent home, but has not been under the necessity up to the present time of paying rent for offices. All the meetings in New York, of the Council and the Institute, have been held at the house of the American Society of Civil Engineers, through whose Secretary, Mr. John Bogart, every possible facility and courtesy has been extended. Several of the scientific and engineering societies of this country, Canada and Europe, are desirous of exchanging publications with the Institute, but so far no place has been provided the Secretary for the accommodation of a library or for the storage of the printed transactions, copies of the rules and other property.

It has, however, been suggested, that the scientific and artistic societies of this city shall combine to secure a permanent, handsome and fireproof structure, wherein to place the valuable libra-

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ries, models, specimens, etc., that are rapidly accumulating in their hands, and where offices and meeting rooms shall be set apart for each of the combined organizations. The Council have, on behalf of the Institute, given their support to the proposition, which is now assuming shape and is under the consideration of a joint committee.

T. C. MARTIN,
Acting Secretary.

May 18th, 1885.

The CHAIRMAN: You hear the report of your Secretary for the past year, what is your pleasure in regard to it.

Dr. NORVIN GREEN: I move that it be accepted and placed on the records of the Society.

Agreed to.

Col. HAZARD read the Treasurer's report.

THE TREASURER'S REPORT.

The American Institute of Electrical Engineers, Cr., in account with Rowland R. Hazard, Treasurer, Dr.

SUMMARIZED ACCOUNT.

To Cash received from Members		$2,315 00
By T. C. Martin, Sec'y, (6 months)	$300 00	
" N. S. Keith	441 22	
" Printing	594 26	
" Stationery and Books	70 25	
" Copying	10 00	
" Signs	10 00	
" Petty Expenses	28 95	
" Balance in Bank	860 32	
	$2,315 00	$2,315 00

E. and O. C.

ROWLAND R. HAZARD,
Treasurer.

New York, May 19th, 1885.

On motion of Dr. GREEN, the Treasurer's report was accepted and ordered to be placed upon the records.

Mr. PHELPS: I offer the following resolution:

Resolved: That the thanks of this meeting be tendered to the American Society of Civil Engineers and to Mr. Bogart, the Secretary, for the use of the rooms of the Society for meetings during the past year, and for other valued privileges and courtesies extended to this Institute.

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The resolution was seconded by Mr. MARTIN and carried unanimously.

The CHAIRMAN: The Secretary is requested to send a copy of the resolution to the Society of Civil Engineers and another copy to the Secretary of that Society.

Mr. F. L. POPE: Mr. Chairman, I have a resolution I would like to offer:

Resolved, that the thanks of the Institute be tendered to Dr. Norvin Green, for the active interest he has taken in the welfare of the Institute and for his invaluable services as its President during the past year.

The resolution was seconded by Mr. F. W. JONES.

The CHAIRMAN: Gentlemen, you have heard the motion. I think there cannot be two opinions concerning the value of Dr. Green's services to the Society. His name is of world-wide significance and nothing could have added more to the importance of the undertaking in the public estimation, I am sure, than the fact that he occupied the presiding chair. If it be your will that this resolution pass, you will say Aye.

The resolution was carried unanimously.

Mr. JONES: I think it is due that we should give an expression of our thanks to our retiring Secretary, for his very valuable services. I have not written it down, but it is quite as good orally, and I would make a motion that we tender to our retiring Secretary, Mr. Martin, our thanks for his attention and for the ability with which he has discharged his duties.

Mr. F. L. POPE: I would second the motion, Mr. Chairman. I am sure we all appreciate Mr. Martin's services. He stepped into the breach at a critical time; he has carried on the work with great inconvenience to himself, has always attended every meeting punctually, and I am sure we all owe a great deal to him—a great deal more than we can express by any resolution for the service he has been to us.

The CHAIRMAN: You hear the motion, gentlemen. I most heartily concur in it myself and I suppose that every member of the Institute who is at all aware of the importance of Mr. Martin's services to us, at a period when there was literally no one to attend to the affairs of the Institute, except himself, most heartily concurs.

The resolution was carried unanimously.

The CHAIRMAN: Mr. Martin will collect the ballots for Mr. Sargent's election.

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Mr. SHERBOURNE: The committee to canvass the ballots beg to report that the whole number cast was 84, of which 68 were cast as printed. In regard to the election of a manager to supply a vacancy Mr. Sargent received a unanimous vote. The ticket, as printed, is therefore elected by a very large majority.

The CHAIRMAN: The Chairman of the Committee of Scrutineers, so-called in our fundamental law, has reported to you, gentlemen, the election of the officers for the ensuing year, and they are: President, Dr. Norvin Green; Vice-Presidents, D. H. Bates, A. E. Dolbear, Francis W. Jones; Managers, Charles L. Buckingham, David Brooks, T. C. Martin, George M. Phelps, Jr., Prof. B. F. Thomas and W. D. Sargent; Treasurer, Rowland R. Hazard; Secretary, Ralph W. Pope. These gentlemen are elected by nearly a unanimous vote as your officers for the ensuing year.

The CHAIRMAN: Our business, I think, is concluded for the evening, and I beg to call it to your attention, gentlemen, that to-morrow the general meeting occurs here at ten o'clock in the morning, and will continue through the day with some refreshments that have been provided at noon time or thereabouts. Five papers will be read, "The Protection of Electrical Inventions," by Mr. Frankland Jannus; "The Storage Battery in Commercial Use," by Mr. E. P. Roberts, M. E.; "The Cost of Mine Lighting," by Mr. F. P. Mills; "The Electric Arc Lamp Frictional Clutch," by Mr. Edward P. Thompson, M. E.; and the "Delany System of Fac-simile Telegraphy," by Prof. E. J. Houston. A collation will be provided between the morning and afternoon sessions and members are permitted to introduce friends. Is there any other business before the meeting?

Mr. MARTIN: I have no business as secretary, Mr. Chairman. I would like to advise members that if they wish to make any amendments to the rules, now is the opportunity. Any notices given now can be considered to-morrow.

The CHAIRMAN: What, if any, amendments occur to you, Mr. Martin?

Mr. MARTIN: A great many, sir.

The CHAIRMAN: I mean of any moment. The Secretary naturally is the one to discover any defects in the working of the organization.

A MEMBER: I should like to ask, if it needs a formal amendment to change the word scrutineers to something else. It

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sounded very funny a year ago, and when the word came to be applied to myself, personally, I did not like it.

The CHAIRMAN: I am not surprised that any one should resent the application of that term to himself.

Mr. SHELBOURNE: I learn that the word was brought into the rules of this Society from the Society of Mining Engineers, and I can readily understand how a Society of Mining Engineers who have to do with caverns under the earth, should peer and "scrutineer" around in order to see something. I make the formal motion, that the rules be amended by substituting in the place of the word "scrutineers" the word "tellers." The word tellers is recognized in the Revised Statutes of this State as belonging to those persons who count the votes at an election of directors or trustees of a corporation, and it seems to me that that word would be more appropriate and sound better.

The motion was seconded by Mr. Martin.

The CHAIRMAN: The word scrutineers is certainly preposterous, if nothing else. Is it your pleasure that the rules be amended by striking out that word?

Mr. SHELBOURNE: I beg to say that, as I understand the rules, the amendment cannot be adopted at this meeting. My motion is therefore, that it be written out and proposed as an amendment here this evening to be considered by the meeting to-morrow.

Mr. MARTIN: The eighth rule provides, Mr. Chairman, that these rules may be amended at any regular meeting by a two-third vote of the members present, provided that written notice of the proposed amendment shall have been given at a previous meeting. That written notice should be given in to-night and the matter can be considered to-morrow.

The CHAIRMAN: Then the motion is that a written notice be now given.

Mr. MARTIN: With regard to the rules generally, there are one or two points that really deserve consideration by the members. Of course, it is natural, that in adopting rules various points should be overlooked and their deficiencies found out only when the members come to work under them. In rule 5, for instance, relating to elections, there seems to be a contradiction. It says this: "The annual election shall be conducted as follows: Nominations may be sent in writing to the Secretary, accompanied by the names of the proposers, at any time, not less than thirty days before the annual meeting; and the Secretary shall, not less than

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two weeks before the said meeting, mail to every member or associate (except honorary members) a list of all the nominations for each office so received, stamped with the seal of the Institute, together with a copy of this rule and the names of the persons ineligible for election to each office. And each member or associate, qualified to vote, may vote, either by striking from or adding to the names of the said list, leaving names not exceeding in number the officers to be elected, or by preparing a new list, signing said altered or prepared ballot with his name, and either mailing it to the Secretary or presenting it in person at the annual meeting."

You will notice that he may add to the list, although he has not made the nomination which is provided for at the beginning of the rule. It is a stultification. I experienced that difficulty in trying to work the rule. It throws a great deal of unnecessary work on the Secretary, for, after he has done all that has been provided, a member may scratch the ballot through and make the nomination even at the present hour of the annual meeting.

Then there is another point with regard to membership in connection with Rule 2. This, as several of the members know from correspondence with myself, is a point that is not at all clearly understood. The rule provides, that associates shall include persons practically and officially engaged in electrical enterprises; it being already provided that members and honorary members shall be professional electrical engineers and electricians. I fail myself to distinguish the difference that is there implied. The council, in working that rule, experienced difficulty at the very first, and in order to mark out clearly its view with regard to the qualifications for a member, it provided the following conditions upon which all associates or others wishing to become members should enter as members.

"Qualifications for a member: He shall have practised on his own account or in the service of some individual, or organized institution or company engaged in electrical work, in the capacity of electrical engineer or electrician, for at least two years, or he shall be so intimately associated with the science of electricity, or the art, that the Council consider his admission to membership would conduce to the interests of the Institute."

I find that in the working of the rules, that a great many take offense at the idea that they are not able to come into the Society directly as members, and they contend that rule 2 provides, that they can come directly into the Society as members without pass-

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ing under any such restriction as that, subsequent to their balloting. I should be very glad to have that point dealt with for the benefit of my successor. I know it will relieve him from a tremendous lot of unnecessary correspondence. We have at present some sixty or seventy full members, and in almost every case I have had to explain what that means, and I am afraid that the idea is very confused and misty in the minds of most of the members, and I am willing to confess that it is somewhat confused in my own. I would like to have that point dealt in some shape, although I am not prepared to move an amendment. There are one or two gentlemen present with whom I am in correspondence at this time on that point. They have brought gentlemen into the Society who are electrical engineers in the fullest sense of that word, and I have had to write to them that they can be only associates. The Council will have to say whether they can be full members or simple associates, and gentlemen take exception to that.

The CHAIRMAN: You might appoint a committee to revise the rules.

Mr. MARTIN: I think I have written at least a hundred and fifty letters on that point, and it seems to me it should be unnecessary on such a material point.

Mr. F. L. POPE: I think it would be an excellent idea to appoint a Committee of Revision and put on that committee some of the persons who have had practical experience in trying to work the rules as they are now. It is perhaps a little misty what the author of the rule did mean by what he said. I must confess that, like Mr. Martin, I do not understand it, and I think that a committee, familiar with the subject, could hit on some plan of modification that would be self-explanatory and which would do away with most of the difficulties that the Secretary speaks of. I make the motion that a committee of three be appointed by the chair to prepare such amendments to the rules and submit them to the Institute.

Mr. MARTIN: I second that motion, and in doing so, I would like to say that the President of the Society has rather strong feelings on the subject. He thinks that that rule more than any other calls for revision and has so expressed himself, I think I am at liberty to say, in the council meetings.

Mr. SHELBOURNE: It seems to me that under the rules, as they now stand, this committee, being appointed at the present time, would have to consider and report this evening, in order that a

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written notice of the proposed amendment could be submitted to the members to-morrow.

The CHAIRMAN: I think the subject rather large to deal with this evening. We had better leave it.

Mr. JANNUS: I think, by a rather liberal construction of these rules, we might appoint a committee with instructions to report at once as a notice, and consider their report to-morrow.

Mr. MARTIN: There are two other points to which I wish to call attention, if I am not boring the members. It says here in Rule 6: "The Annual Meeting of the Institute shall take place on the 3d Tuesday of May, at which a report of the proceedings of the Institute and an abstract of the accounts shall be furnished by the Council. Two other regular meetings of the Institute shall be held in each year, at such times and places as the Council shall select, and notice of all meetings shall be given by mail or otherwise, to all members and associates, at least twenty days in advance. Special meetings may be called whenever the Council sees fit; and the Secretary shall call a special meeting on a requisition signed by fifteen or more members." It will be seen that to-morrow's meeting is entirely distinct and independent of this, and in that way there is full propriety in considering any amendments that may be presented; but there is a point in connection with the rule. Several of the members in New York have written to me and have objected to the infrequency of the meetings held during the year. They say that the members ought to be brought together in New York oftener, that papers might be presented and read, and that the New York members might form a branch or a sub-section of the Society, and they think that the Society would be greatly strengthened by some such step as that; but it will be seen that Rule 6 makes no provision at all for any meetings of that nature, except that they shall be called whenever the Council sees fit, and that the Secretary shall call such a meeting on a requisition signed by fifteen or more members. It seems to me that the Society would derive benefit from occasional meetings of the New York members. The New York Electrical Society has papers presented in that way, and a great many of them are of interest and value.

The CHAIRMAN: I think a committee to consider these rules ought to have time, and I think, if a committee was appointed to-night, there will be no necessity for them to report to-morrow, as a special meeting may be held within thirty or sixty days. We

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have gone through the first year and it would seem that all the amendments that are likely required would be already perfectly clear in the minds of the Executive Officers of the Institute. It would seem to me, therefore, if we should appoint a committee to-night to report whenever a special meeting is called, within thirty or sixty days, we might also make that an interesting occasion for other reasons. That would give some little time for everybody to consider these rules and to confer with the committee as to the propriety of changes. I understand it to be moved that a committee of three be appointed by the chair to report. The question is, shall it be to-morrow or at the next meeting.

Mr. JANNUS: I suggested that it report at once for the purpose of overcoming the technical difficulty in the way of Mr. Martin's successor. I shall withdraw that, of course, in view of the suggestion of the chair. If the committee intends to go into the subject deeply enough to afford permanent relief, I think it would be far better for the Council to call a special meeting to consider their report.

Mr. JONES: I think that it is highly important that the Institute should place itself properly before the electrical talent of the country, and that as soon as possible they should know their status. Now it seems to be defined in a peculiar manner, as has been pointed out by the Secretary, and a person who is engaged in any electrical work hardly knows whether he is elegible to come in as a member or associate. The same prevails in other professions; you will find signs in the street of professional haircutters and practical haircutters. I do not see the distinction. Then there are practical tailors; what a theoretical tailor may be I do not know. I think, if we take steps to-night to have that particular part rectified, it would be the means of a large accession to our membership. But if it is left for a few months, it will deter persons whom we will be very glad to have connected with us, from sending in their names.

Mr. F. L. POPE: I think it would be an excellent idea for this committee to invite suggestions from all the members as to any alterations in the rules that they may think advisable, and in that way they will probably get some suggestions that would be worthy of consideration, and it might be well to invite such suggestions at the meeting to-morrow from the members then present. I think the committee will find it of material aid to them.

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The CHAIRMAN: That committee might report on the 10th of June, for example, in order not to defer it too long.

Mr. JONES: Have an adjourned meeting from to-morrow.

Mr. PHELPS: I think, Mr. Chairman, the motion might be put in some such way as this: That a committee be appointed to prepare a general revision of the by-laws wherever they think it is required, and to report within some specified time and request a meeting to be called at once thereafter. It seems to be a very important question, and I have no doubt a very large attendance will be secured at such a meeting, and the committee might finish its labors in ten or fifteen days possibly; but I certainly feel that the matter requires very careful consideration and nothing need be done in a hurry.

Mr. MARTIN: I have been in correspondence with gentlemen who wanted to join, and simply because they could not come in as members in the full sense of the word, they have ceased their correspondence. If they knew exactly the conditions upon which they were to enter the Society, I think electricians would come in much faster than they do now. It has been no small burden to me for the last six months to explain what that rule meant.

Mr. SHELBOURNE: It seems to me, with regard to this special meeting, the difficulty will be that, being a special meeting for this purpose, it will not be largely attended. To-morrow being the general meeting after the annual meeting, I assume that there will be a large number of members in New York city, who are here for the purpose of attending this meeting and hearing the papers read. As the principal thing to be done in regard to these rules is in regard to that one in relation to the qualifications of members and associates, I would suggest that an amendment of that rule might be made at once by the committee, so that that could be considered to-morrow and suggestions could be received at the meeting to-morrow, and if the meeting did not propose to adopt it to-morrow, then the meeting to-morrow might defer the adoption of it until some other time. It would be desirable to take the views of a large number of members or associate members, as they may be called, it seems to me, to-morrow on this subject, in order to have the matter put in as nearly practical a shape as possible, as soon as possible. As for myself, I was among the first to sign the rule for the membership of the Society, and I never stopped to consider whether I was an associate member or a member, because I never have been able to discover and I have

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never been informed that there is any difference in the amount of collation we will receive to-morrow whether we are members or associates; or in relation to any of the privileges or emoluments of this Society (if there are any emoluments), as to whether we are members or associate members. But I learned to-night for the first time that there is a great feeling on this subject, and I think the question ought to be begun to be settled as soon as possible.

The CHAIRMAN: Suppose that the regular meeting to-morrow shall adjourn to the 17th of June, the subject could be continued. I am strongly inclined to think that you could not modify that rule satisfactorily at very short notice, particularly as the committee ought to consist in the nature of things of the outgoing and incoming Secretary and President.

Mr. JANNUS: I would like to ask, if this printed memorandum would make a satisfactory change in the rules:

"He shall have practiced on his own account, or in the service of some individual, or organized institution, or company engaged in electrical work, in the capacity of electrical engineer, or electrician, for at least two years, or he shall be so intimately associated with the science of electricity or the art, that the Council consider his admission to membership would conduce to the interests of the Institute."

Mr. MARTIN: That has been considered satisfactory to every gentleman who has seen it; but the point is this—a gentleman presents himself for entrance in the Society; he says, "I am an electrical engineer engaged in electric lighting; can I become a member?" I have to send word back to him and say: "No, you can become an associate, and if the Council say so, you can become a member;" and they take umbrage. The Council has rejected the application of two or three associates in view of that clause.

Mr. F. L. POPE: I think it is rather important there should not be any hasty action taken on those rules. When we amend them this time, we do not want to have to do it over again. We might as well make a thorough job of it, and I think we have had sufficient experience in working the rules, to find out most of their defects, and it has occurred to me, that we might get at the sense of the whole society perhaps in this way, by having the committee prepare a draft of the rules, have them printed, and a copy sent to every member to invite suggestions, before presenting it in this

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final form, the committee being, of course, at liberty to adopt such suggestions as they please, or to pay no attention to those that they do not consider worth paying attention to. In that way every one would have a hearing, and no one could complain that his ideas had not been considered, and it would not take very long to do that, and the probability is that very few amendments would be suggested, so that I presume we should find the rules would be left substantially as the committee decided upon them in the first place.

Mr. SHELBOURNE: I indorse that view very thoroughly.

The CHAIRMAN: The resolution then would take the form, that a committee of three be appointed for the revision of the by-laws of the Institute, and that they be requested to report to a general meeting to be held within the month of June, which meeting shall be an adjournment of the regular meeting to-morrow. When the meeting to-morrow adjourns, it will adjourn to Wednesday, the 17th day of June, or a meeting might be called by the Council on the 17th of June.

Mr. MARTIN: Wouldn't it be better after all to give the committee time and adopt Mr. Pope's suggestion of a thorough canvass of the members, so that it can come up at the next regular meeting. I think three or four months is not a very long time to wait.

The CHAIRMAN: Then the committee, when it is ready to report, will request the Council to call a special meeting.

Mr. F. L. POPE: That will be better, I think.

The CHAIRMAN: Then the resolution will simply be for the appointment of a committee of three for the purpose of revising the by-laws and with power to adopt such a course to ascertain the consensus of opinion as they may elect to do and to report, and with authority to request the Council to call a meeting.

The resolution was adopted.

The CHAIRMAN: I will appoint as committee on the last resolution, the retiring Secretary, the incoming Secretary, and Dr. Green.

Mr. SHELBOURNE: In view of the motion just passed I ask leave of the meeting to withdraw my motion in regard to the word scrutineer, and let that subject come before the committee for action with the rest.

THE CHAIRMAN: There is no objection to that withdrawal.

The Secretary suggests that I say something about a plan for

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securing a permanent home for the Society. A committee of four has been appointed by this Institute and a larger committee by the Society, which is our host here, and committees have been appointed by one or two other societies. The general plan is to get one of the large estates like the Astor or Rheinlander to put up a large fire-proof building to accomodate twenty-five or thirty societies, which have common purpose, scientific or artistic, in preserving their records, their libraries and their specimens, and to make a common rallying point for the scientific and artistic world in this city, which is the commercial centre of the United States. That committee that has it under consideration, has had one meeting and is to have another, and is in treaty with one or two estates. It is thought, that with thirty or forty societies, particularly if we could include societies of considerable membership and age, like the Historical and Geographical societies, that a great estate would think them good tenants and be glad to take them on a lease of twenty-five years, so that a permanent home for the sciences and arts could be had here. I do not know that any action of the Society is desirable at the present moment, but we very much hope that the committee will be able to report soon that an arrangement has been made to accomplish that greatly to be desired end.

Mr. MARTIN: I would like to say with reference to our Chairman's very interesting statement, that is highly desirable we should have some sort of place we can call our own. It would be far more interesting to the members to know that they have a place where they can go, a place that will compare in some sense with this, in after years. I may say that I have now on my hands some three or four hundred dollars worth of property, and I think that that should be deposited in some place. I have at least seven hundred copies of the Transactions and two or three thousand copies of the Rules. I have had several applications from various societies in Europe and here for an exchange of proceedings, but in every case I have had to decline present acceptance on the ground, that I have no place in which to deposit such valuable papers that might be sent in exchange, and I think it would be very encouraging for the Council, if they could have in any shape an expression of opinion from the Society of approval of the step that was being taken in this matter in joint action with the other engineering and artistic societies.

Mr. F. L. POPE: I would like to make a motion that the

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Council be authorized to hire a small room at moderate expense in some convenient and safe place for the storage of their records and books, etc., temporarily for the coming year or until we get quarters of our own of some sort. It would be much better to do that, and it would cost us but very little. I think it would be an excellent thing to do. It need not be an expensive room or a large room, or in a very conspicious place. It could be used mainly for the storage and keeping of the property we have, and if the Society will authorize the Council to procure such a room, and leave it to their discretion, I think it can be arranged without any difficulty.

Mr. MARTIN: I would like to say, sir, as an instance of the necessity of some such place, that at Philadelphia there were many interesting exhibits which the exhibitors were anxious to hand over to the Society. But we had no place to put them, and the Franklin Institute has profited by our want of such a place. I do not begrudge them to the Franklin Institute, but I think it would be very desirable to have a museum for the Society, which might be of great value by and by.

The motion to authorize the Council to secure a room was carried.

Mr. JONES: It has just occurred to my mind that our esteemed President is pretty well burdened in duties. He has been very attentive at all our Council meetings, and has had considerable committee work given to him, and I have just heard his name mentioned in connection with a very important work for us, and while he would be eminently fitted to carry out the work, had he the time; I do not think it would be right for us to impose on him to that extent, and then we have electricians and others in our own ranks to such extent, that we are capable of keeping young men for labor and old men for council, and I think it would be proper to relieve our President from that duty. I am not a candidate for that office, nor am I able to perform its duties.

Mr. F. L. POPE: It seems to me, Mr. Chairman, that we need not throw a great deal of the work on our respected President, and in fact, I think, your idea in appointing him was, that he should have the casting vote, as it were, and have the work done by the other members of the committee submitted to him, rather than to impose upon him any active duties in connection with it. I do not think that is necessary. I think the retiring and the in-

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coming Secretaries can lay out the work, and I think it would be eminently advisable to submit it to Dr. Green for his suggestions, as he has had a great deal of experience in matters of this kind, and as we all know, is a man of remarkable common sense about such matters. I hardly think that we need deprive ourselves of the benefit of his counsel on that committee.

Mr. JONES: I agree with all Mr. Pope has said, and I beg to say that Mr. Green is an ex-officio member of that committee anyway.

THE CHAIRMAN: The only thing I object to in the resolution is, that Dr. Green is spoken of as an old man. If you are to judge a tree by its fruits, he is still young. I think that Mr. Martin and Mr. Pope are both competent to deal with that subject, and that the committee is a good one as it stands. Dr. Green's counsel will be desirable and it has been stated by Mr. Martin, what I did not know before, that he has a good deal of feeling and a distinct opinion on that subject. I think that had better stand, unless it is the sense of the meeting otherwise. The objection has been made to me, that no member of the committee is an active electrician, but I do not know that that is a serious objection. They are both very sensible men and both have had considerable experience in this particular department. Mr. Martin has given much attention to that rule and has lost in mind, body and estate through it.

Mr. MARTIN: I would like to say that I would be glad to give a good deal of time to the revision of the rules, and I would also like to inform our Chairman, that Dr. Green at one of the very few meetings, from which our Chairman was absent, expressed himself in very strong language indeed with regard to that rule. I think Mr. Pope was present and will bear me out in that statement. He spoke to the point for several minutes and expressed his earnest wish to have some reconsideration of that rule, so that it be in one sense more liberal and in another sense more restrictive, that it would take in all who were worthy and at the same time let those who were not, know it. As it is now, it is vague in the extreme. I would like to have a professional electrician (I am not one) on that committee.

Mr. JONES: That was my idea exactly. There is not a professional electrician on that committee.

Mr. MARTIN: I should be very reluctant to pass dogmatically on what constitutes the status of professional electricians? Will Mr. Pope serve on that committee with us?

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M. F. L. POPE: I do not object, sir.

Mr. JONES: Make the committee five, and I would like to include Mr. Hamilton.

The CHAIRMAN: It is moved that the committee be increased to five, and that Mr. Pope and Mr. Hamilton be added to the committee.

The motion was carried.

The meeting then adjourned.

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GENERAL MEETING.

THE General Meeting was called to order at 10 A. M. on May 20th. Mr. SHELBOURNE in the Chair.

Mr. MARTIN: I move that a committee be appointed by the Chair, to determine the order of the presentation of the papers to be read at this session.

Agreed to.

The CHAIRMAN: I will appoint Mr. Hamilton, Mr. Pope and Mr. Phelps as that Committee. If the Committee will retire to the rear room with the Secretary, they can confer there and report as soon as the matter is determined.

The Committee then retired.

The CHAIRMAN: The Committee have reported and the order has been determined as follows: The first paper to be read is "The Protection of Electrical Inventions," by Mr. Frankland Jannus; second, "The Cost of Mine Lighting," by Mr. F. P. Mills; third, "The Electric Arc Lamp Frictional Clutch," by Mr. Edward P. Thompson, M. E.; fourth, "The Storage Battery in Commercial Use," by Mr. E. P. Roberts; fifth, "The Delany System of Facsimile Telegraphy," by Prof. Houston. The first paper therefore in order, will be "The Protection of Electrical Inventions," by Mr. Frankland Jannus, who will now proceed to read his paper.

[The reading of the various papers and the consequent discussions then followed in their regular order, as they appear herein. After the discussion, on Mr. Thompson's paper, an intermission of two hours occurred, during which the members and guests partook of a collation. The opening business of the afternoon session then followed, after which the regular order was resumed, beginning with Mr. Robert's paper.—EDITOR.]

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AFTERNOON SESSION.

The meeting was called to order at 2.30 P. M.

The CHAIRMAN (Mr. SHELBOURNE): Your Chairman asks for relief from duty as chairman of the afternoon session.

Mr. F. L. POPE: I move that the Chairman be excused, with the thanks of the meeting, for the courteous and agreeable manner in which he has presided over our deliberations, and if it is in order I would nominate Mr. Frankland Jannus, of Washington, as our presiding officer for the afternoon session.

The nomination was approved and Mr. Jannus took the chair.

The CHAIRMAN: Before proceeding with the reading of the next paper, I have to announce the receipt of a telegram from Mr. George C. Mason, Secretary of the American Institute of Architects: "To the Secretary of the Electrical Engineers: Regret inability to be at your annual meeting. Accept best wishes and fraternal greetings."

Mr. MARTIN: Captain Michaelis has a resolution to offer on the subject of electrical units, and also in regard to the investigation of structural materials, and Mr. Roberts has kindly consented that his paper be deferred until this matter is disposed of.

Capt. MICHAELIS: I must apologize for encroaching even for a very brief period upon the attention of the Institute, and also for being instrumental in deferring for a few minutes the paper of Mr. Roberts, in which we all are interested.

You may recollect that last fall, at the meeting of the National Conference of Electricians, among whose members I notice that the Institute is so largely represented, a motion was made, after an animated and prolonged discussion relative to the Governmental establishment of electrical and other units, that a committee be appointed to attempt to secure government aid in such establishment, and also, that the same course be taken in reference to the electrical investigation of the physical qualities of structural materials, a matter in which all engineers of every name and kind, are exceedingly interested, and in order to merely test the sense of the Institute whether it be considered a proper subject to be acted upon by its representatives, I thought it best to crystallize the matter into a resolution, which I have drawn up very hastily and which, of course, is subject to verbal and other amendments:

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Resolved, That the Chairman appoint a committee of five members, to act independently or with a similar committee appointed by the President of the U. S. Electrical Commission, for the purpose of obtaining Government aid in the establishment of electrical and other standards, and in the electrical investigation of the physical quantities of structural materials.

I put in the word independently, because the committee appointed by this Institute might be in shape to act at a time when perhaps the other committee might not be, and it was simply to give them that latitude that I put in that modifying clause.

The CHAIRMAN: Do you think the Conference would co-operate with a committee of this Institute?

Capt. MICHAELIS: I think so. There are others here, beside myself, who are members of the Conference. I propose to bring the subject to the attention of the President, Prof. Rowland of the Johns Hopkins Institute.

Mr. MARTIN: I would like to ask whether that could not be more closely defined, as to whether the Council or members is meant.

The CHAIRMAN: Does the mover of the resolution desire that this committee be appointed by the Chair or by the Council?

Capt. MICHAELIS: Whichever way would be most expedient. There is no immediate hurry for the appointment of a committee. Let it be the President of the Society or the Council, whichever is the usual course. I know that in kindred societies of which I am a member, it is usually the permanent president of the society who appoints such committees, after he consults, of course, with his "constitutional advisers."

The CHAIRMAN: The reason I asked the question was, that the Council is the permanent governing body here, and they would perhaps be far better able to appoint a committee than the temporary Chairman.

Mr. MARTIN: I move that it be amended by substituting Council for Chairman.

Capt. MICHAELIS: I accept the amendment.

The resolution was adopted.

The CHAIRMAN: We will pass now to the reading of the fourth paper, the title of which is "The Storage Battery in Commercial Use," by Mr. E. P. Roberts.

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PRELIMINARY REMARKS ON THE DELANY SYSTEM OF FAC-SIMILE TELEGRAPHY.

The CHAIRMAN:—The fifth and last paper for to-day relates to the Delany System of Fac-simile Telegraphy, by Prof. E. J. Houston, of Philadelphia.

Mr. MARTIN:—Prof. Houston is ill and not able to be present, and under those circumstances I have asked Mr. Pope to read the paper. It did not reach me until between 4 and 5 o'clock yesterday afternoon. It is not altogether easily decipherable; but Mr. Pope has kindly volunteered to read it, although I fancy he must have experienced some difficulty in making out its contents. In case he has not been able to read it through, I suggest that he make a general statement on the subject and that the paper be taken as read; if that course is agreeable to Mr. Pope.

The CHAIRMAN:—If there is no objection that course will be pursued.

Mr. F. L. POPE:—This paper has only been placed in my hands since I came here this morning and I have snatched a few moments, as I had opportunity to look over it. It is accompanied by a number of diagrams, which, if I were more familiar with the subject, I might sketch out on the blackboard. Instead of attempting to read the paper it may perhaps be sufficient as we shall have it printed in due time to give a brief summary of what I think is in it.

Mr. Patrick Delany exhibited at the Philadelphia Exhibition, last year, a synchronous multiplex telegraph. This telegraph was shown in successful operation, and probably many of those here present had an opportunity to inspect it; possibly some may also have seen it in operation between Boston and Providence, where it was in practical use some time ago and I presume is to this day. I had an opportunity of examining it at work between Boston and Providence, in company with Mr. W. H. Preece of the British Post Office Telegraphs, who was over here last year, and its operation was quite satisfactory. The wire on which it was working was not far from one hundred miles in length, reaching from Boston to Providence and back to Boston again, and over this length of line, I consider that the transmission of messages six and eightfold was practically successful. I am sure we all regret that Prof. Houston is not here to read the paper himself, as he would have made the matter very interesting and very clear. He

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has taken a great deal of interest in Mr. Delany's system and has afforded the inventor a great deal of valuable assistance in bringing it before the public.

[Mr. Pope then gave an explanation of the fac-simile system of Mr. Delany, which is omitted, the paper appearing elsewhere in full. EDITOR.]

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DISCUSSION.

The CHAIRMAN: I think the subject of fac-simile telegraphy, referred to in the paper, is a most interesting one, and one which ought to be discussed. I think it is the last possible step in telegraphy to transmit a person's actual handwriting, and I feel that there must be some latent information in the Society on the subject which ought to be brought forward.

Mr. G. A. HAMILTON: This is so much of a subject, and it is now getting so late, that it would be better to defer the discussion until another meeting and let the members have an opportunity meantime to familiarize themselves with the paper.

The CHAIRMAN: I am afraid, Mr. Hamilton, if we do, that some other paper will come up, and we shall all have to be satisfied with the plain record of this paper. I think, if we could talk about this now, it would be advantageous, because the discussion goes on record and will be scattered broadcast with the paper itself.

Mr. R. W. POPE: What particular advantage has this system in practical use?

Mr. HAMILTON: I fancy it is to get greater speed. Hitherto the fac-simile systems have been so slow in practice as to be of no account commercially speaking. As we have not had all the details of the paper, I do not see how we can very well discuss it intelligently.

Mr. ROBERTS: I would like to ask Mr. Pope, if the fac-similes which he told us he saw were in large coarse handwriting, or whether the writing was small, and if it was small, was it so legible as to be easily recognizable.

Mr. F. L. POPE: The specimen I saw was quite a large and coarse writing. I should say the letters were a quarter of an inch high; but at the same time it was sufficiently distinctive, so that it could be recognized in most cases. While we are upon this subject—a gentleman has just asked what the advantage of the fac-simile telegraph is, and it must be said that the advantages of it, if there are any, lie in a very different direction from what most persons would be likely to suppose. It has always been taken for granted, by those not familiar with the details of telegraphic service, that if all communications could be sent in the actual handwriting of their author, there would be some particular and very important advantage in it. As a matter of fact there is no advantage whatever in it. I was shown a few years

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since, in France, the Caselli telegraph, working between Paris and Marseilles, and working very beautifully too. Fine close handwriting, such as you would put on a postal card, was transmitted with reasonable rapidity and with very great perfection. I was informed by the officers of the telegraphic administration that they had had it in use for some years on that particular line, for the reason that there was a great deal of financial business transacted between Paris and Marseilles, in the way of drafts and messages relating to the payment of large sums of money, and it was thought it might be very important, if on that particular line the message could be delivered when required in the handwriting of the sender. But I was told that practically it was very little used, except as a matter of curiosity; that when people had financial messages to send they preferred, for the most part, to send them in cipher in the ordinary way.

There is, however, another aspect of the subject, which is perhaps less apparent at first, and that is this: If it were possible to construct a purely mechanical fac-simile system, by which the original message, as the customer writes it at the counter, is thrown immediately into a hopper as it were, and not otherwise touched by human hands, while its fac-simile is ground out at the other end of the line ready to put in an envelope and sent to the correspondent, we should have a practical solution of the much discussed problem of "cheap telegraphy." It is certainly in that direction that we are to look for the solution, if it is to come at all. When I say "cheap telegraphy," I mean a system which is as rapid as the Morse system and as cheap as the Post Office, and that, I think, is the real point of interest in connection with autographic electric transmission. I regard all these attempts to realize fac-simile telegraphy in practice as so many steps in the direction of that universal telegraph which some of us may live to see, in which the work of transmission and reception will be purely mechanical, and the only skilled service needed will be that of the electricians and engineers who keep the apparatus and lines in order and look after their proper working.

Mr. MARTIN:—I had a specimen of Mr. Delany's work in my possession which purported to be a portrait. I would like to ask whether that system could be so materially improved as to send the portrait, say of Maxwell the alleged murderer, from St. Louis to San Francisco, or even under the sea to distant lands. I mean in such shape as the outline portraits in the daily journals not the gross libels, but the more accurate and artistic ones.

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Mr. F. L. Pope:—I see no reason to doubt its perfect practicability. This Caselli system would certainly send good outline drawing in better shape than those we see in the daily journals. Although Mr. Delany's specimens are perhaps as yet, not quite up to that pitch of perfection, still I can see nothing in the system which would necessarily prevent it from being made to do as good work as the Caselli system. I have no doubt that it is merely a matter of the perfection of the apparatus.

Mr. R. W. Pope:—This question of recognizing handwriting is perhaps carried to a greater extreme than most persons are aware. At one time—I do not know whether it is the case now—there were banks in this city that would not accept checks where the signatures were written with a stylographic pen, on the ground that the character of the handwriting was determined mostly by the shading and hence they could not judge properly of the authenticity of the signature without the shading. Until we can reach a greater refinement in fac-simile telegraphing than has yet been done, I do not think that point is of any particular value. I do not think some of the messages which are handed in over the counter from day to day could be read by the recipient, unless they had first been translated by an operator who was an expert in handwriting.

Mr. F. L. Pope:—I agree entirely with what the gentleman has said. I have had some experience in that line myself.

Mr. Hazard:—You think you would not have gained anything if Prof. Houston had telegraphed his paper to you by the Delany system.

Mr. F. L. Pope:—If he had telegraphed it to me by the Morse system, and not by the fac-simile system, I think I should have gained a great deal.

The Chairman:—It is suggested that it would be far more convenient and acceptable to the members generally, if the papers that have been read here to-day, together with the discussion upon each, be mailed to the members separately as soon as they have been revised and printed, so that you get one paper within a few weeks and another within a week or two afterwards, and so on, instead of waiting until the volume is ready. This can hardly fail to be more satisfactory to everybody. It seems to the chair a very good plan, and I would suggest that unless there is objection to it, it should be followed.

Mr. Hamilton:—I think the council considered that at one time, and favored it.

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Mr. MARTIN:—I had the preparation of the first volume in my hands, and had considerable trouble in getting the proofs back from the members. That is the reason why the pages are not numbered consecutively. Now, if the papers are taken in the order of their presentation here to-day, and the discussion is written out and each paper sent out as it is proof-read, the members will at least have something to keep the society in their mind, The pages will be numbered consecutively and then, if it is desired complete bound volumes can be issued by the Secretary.

Mr. F. L. POPE:—There is apparently no objection to that, except the slightly increased expense, which is probably not worth taking into account.

The CHAIRMAN:—Let me call your attention to the programme for to-day. We have had discussions here to-day upon the following subjects:—Protection of Electrical Invention, Patent Law, Mine Lighting by Electricity, Arc Lamp Mechanism, Underground Electric Light Wires, Lightning Rods, Secondary Batteries, Incandescent Lighting by Central Stations and Isolated Plants, cost of Gas and Electricity, and Fac-Simile Telegraphy. It seems to me that this is a very good programme and that we have really done an excellent day's work. I believe it will make a good showing for us, and one that we need not be ashamed of in future years.

Mr. MARTIN:—Before the meeting adjourns, I move that a vote of thanks be tendered to Mr. Jannus for the able manner in which he has presided over the session this afternoon.

Agreed to.

The meeting then adjourned.

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Read before the American Institute of Electrical Engineers, May 20, 1885.

THE PROTECTION OF ELECTRICAL INVENTIONS.

BY FRANKLAND JANNUS.

It having been suggested that a few words on the above subject may be of interest, the following brief outline of the bearing of recent decisions upon patent interests is submitted, together with such comments and remarks as seem necessary to indicate their apparent application and importance.

The tendency of invention at the present time is toward improvement in the details of the great inventions that have brought the science of electricity so rapidly, prominently, and no doubt permanently, to the notice of the unthinking, as well as thinking, people of the civilized world.

As matters stand to-day, the dynamo, the arc and incandescent lamp and devices for regulating and controlling them, the telephone and its accessories, the motor, and the electric locomotive, inventions which form the foundation stones of the great systems of the future; these, in addition to the thousand and one minor applications which are a constant source of wonder to the general public, and sometimes of amusement to the skilled electrician, seem to supply every want, and render further efforts at improvement unnecessary and unprofitable; but it has seemed so from time immemorial, and our opportunities are at least as good as those of our predecessors.

Our laws give the inventor time for public trial and experiment within which to ascertain the practical utility of his improvements, and during which he usually has ample opportunity to discover their marketable value, before expending much time or money thereon.

The history of the Patent Office shows that during the last five years most of the patents granted on electrical inventions have been for improvements upon well-known apparatus. Were this not the case, that department might as well close its doors, for it hardly ever happens that a new system is perfect in its inception, and a single novel and operative device is frequently the subject of a long list of patents.

I take it for granted that you are aware how the Supreme Court

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has almost stopped the reissuing of letters patent by deciding that where the claims of a reissue cover more, or are broader than the claims of the original patent, they are void, because for another invention.

The cure has been so radical, and the reaction so strong, that reissued patents are now looked upon unfavorably, no matter what the reason for the reissue, so that the safest way is to get your patent out in good shape at first, and then stand or fall by it.

The Patent Office is responsible to nobody and guarantees nothing. The unpleasant fact that patents are so often declared invalid by the courts is a warning to inventors that they must see to it before letting a case go to issue, and be governed by decisions, and if necessary, insist upon what they ought to have, *before accepting* the patent, for after that it is too late.

The status of patents for improvements in the details of previously patented devices is generally as follows: The pioneer case, having been properly handled, should contain claims broad enough to cover all obvious changes, equivalents, and modifications, and such claims are generally broad enough to cover important improvements as well, and the question is, what value can a subsequent patent have? Being subordinate to the original, the patentee would not be at liberty to manufacture the article covered thereby by simply adding his improvements to it, nor would his improvements give him title to his predecessor's productions, except of course as to old and well-known elements. For example, an improvement in holders for commutator brushes, or in the commutator itself, would not affect some other person's patented armature, nor an improvement in filaments for incandescent lamps, a method of sealing the same into the globe.

The practice in the Patent Office is supposed to be in accordance with the latest decisions of the courts in patent causes, and it is much more nearly so to-day than in years gone by. We can therefore best form an opinion of what a patent should contain by considering some of those decisions.

A long line of decisions has been rendered by the Supreme Court of the United States in patent cases, and these decisions cover almost every form of question, but they often involve propositions not to be found in the case under consideration, and the latest cases are always looked to and depended upon for a statement of the law as it exists. Some of the recent decisions having a special bearing upon the most numerous class of patents, namely,

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those for combinations of old elements to produce new or seemingly new results, I will bring to your attention the three most recent decisions, which were published only last month, my object being to explain what may be, and usually is, covered by a patent for improvement on some other invention, and also what is covered by a combination claim, in order to convey a fair idea of the scope of such a patent, and the rights and privileges of a patentee under such circumstances.

In the case of *Stephenson* vs. *the Brooklyn Cross-Town Railroad Company*, suit was brought for the alleged infringement of three patents, the first one for the combination of mechanism used by the driver for opening the rear door of a bob-tail street car. The court said "as there is no evidence of invention prior to the date of the application, and as the state of the art at that time shows that neither the separate elements of the devices nor the combination is new, it is held that there is no patentable invention in the contrivance described in the patent, and hence no infringement." (There may have been some novel construction embodied in this case which justified the Patent Office in granting a limited claim therefor which would probably have been held to be good, as far as it went; but there was evidently an attempt to use the patent for more than it was worth by the party bringing suit and it was therefore held to be invalid.)

The second patent was for two bell-cords provided with a system of pull-straps passing along the sides of the street car within convenient reach of the seated passengers, for signalling purposes. "As the evidence shows that long prior to the application such signalling appliances had been attached to the middle of street car ceilings, there was no invention in changing them to the sides of the cars, and hence the patent is void."

The third patent was for a combination of a bonnet, in which was fixed a mirror and an opening in the front door of a street car, by means of which the driver can see what is transpiring within the car without turning his head. "As each element is old, and as neither element performs any new office or imparts any new power to the other, and as all combined do not produce any new result or any old result more cheaply or otherwise more advantageously, this is a mere aggregation and not a patentable combination."

This entire decision is extremely important, and will be much referred to in the future, for the reason that it deals with ques-

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tions arising every day, and states the proposition involved, more fully, clearly, and conclusively, than anything heretofore published.

In the case of *Sargent* vs. *The Hall Safe and Lock Company et. al.*, suit was brought to restrain alleged infringement of letters patent the claims of which were for combinations of mechanical elements. The defendants claimed that they did not infringe, because they did not use the combinations of elements mentioned in the patent. The Court considered the patent upon its face, and then considered the references upon which the application had been several times rejected. Then they took notice of the many amendments and persistent efforts required to secure an allowance, and decided that "in patents for combinations of mechanisms, limitations and provisos imposed by the inventor, especially such as were injected into an application for the purpose of securing an allowance after it had been persistently rejected, must be strictly construed against the inventor and in the favor of the public, and looked upon as in the nature of disclaimers, and further, that the mechanism of the defendant's lock not being the same as that covered by the patent, there was no infringement."

The court did not say that the patent was bad, but simply that in view of the state of the art at the time the patent was granted, with which every inventor is presumed to be familiar, he claimed more than he was the first inventor of, and that while it was perfectly good for what was novel, they did not propose to assist him to recover more than he was really entitled to.

The cases just cited refer to mechanical devices, and you might naturally ask, How does the court regard the combination of electrical elements? The following will throw some light on that question.

In *The Electrical Railroad Signal Company* vs. *the Hall Railway Signal Company*, also published last month, and which was a suit for infringement, it was held that defendants did not infringe, because the claims being for combinations of elements, they not having used the entire combination or substantial equivalents therefor, that they had not rendered themselves liable. The substance of the decision is as follows:

"The patent is for a combination in which the elements were known and open to the public use. Its object was the accomplishment of a particular result, namely, to work electric signals on the block system. But the thing patented was the particular means devised by the inventor to accomplish that result, and to constitute

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in this case identity of invention, and therefore infringment, the result, the elements or their equivalents, and the combination, must be the same, so that each element shall perform the same function.

"In complainant's patent insulated sections of the rails as circuit-closers constitute an essential element in the combinations, the wheels and axles of the train forming an electrical connection between the opposite insulated rails at appropriate places, and so actuating the signal. The defendants dispense with insulated sections of the track, and employ a separate instrument placed near the track, from which the lever connects with the track, and is operated by the passing wheels of the train.

"In complainant's patent, a single battery is used to operate an electric circuit of considerable length by means of two wires or other metallic conductors attached to the positive and negative poles of the battery, and suitably insulated from each other and from the earth. The defendant's plan does not include such a metallic circuit, but uses a circuit composed in part of the earth. In this case the evidence shows the difference is more than a mere substitution of earth for one of the conducting wires. It consists in the use of new elements, a new combination, and a new result."

From the foregoing it will be seen that the legal construction of combination claims is comparatively strict, on the theory that all the inventor has done is to assemble well-known elements in a manner different from his predecessors. He cannot acquire title to those elements except in his particular combination, and any other person is at liberty to combine a greater or smaller number of the same elements, if by so doing they do not attain the same result in practically the same manner. When, however, the invention consists in some new thing having an existence separate from a group of well known elements, then the case is entirely different, and the inventor is entitled to, and the patent should contain, a claim for the thing itself. If the single element is designed to form part of a group, the patent should also contain claims for the combination, and such claim, would, like any other combination claim, be evaded by the omission of any essential portion of the combination, but the element covered by separate claim cannot be used singly or in combination, without liability to the patentee.

Devices may be constructed in which the element is included, and combination claims including said single element may be pre-

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sented, and the Patent Office, if unable to meet the combination with references, would be obliged to allow them, but that does not give the patentee of the combination any exclusive title to the element invented and patented by another; it only gives him title to *his* combination, as against any other similar "combiner" while he himself will have to secure license from the inventor before he may lawfully use that particular portion of his combination.

This, you see, leaves a clearly defined and very large field for the inventor of the present day, for where there is actual novelty, more than mere combination of old devices, such claims can always be obtained as will afford complete protection. One difficulty to be overcome is that of knowing at the time the patent is taken out all the modifications and adaptations of which the invention is capable. There are many cases in which, with the best intentions on the part of all concerned, patents have been less comprehensive than they might have been, and it seems that the only way for an inventor to secure the fullest protection is to consider all the separate and distinct practical applications of his central idea and patent them all, for in this country the cost of a patent is really very small as compared to the privileges granted, and there are no further expenses after the patent has issued, as there are in other countries, where periodical taxes must be paid and conditions as to manufacture complied with, in order to keep a patent alive.

Taken as a whole, I think that our patent system is really as wonderful as our system of government, like which, while offering the greatest prizes to any man whose genius, industry and diligence enable him to secure them, yet the acquisition and the enjoyment depend almost entirely upon the individual.

The law assures the full enjoyment of privileges acquired, but guarantees nothing until the individual has, by proper proceeding, perfected his title to the thing desired.

That thousands of worthless patents are granted every year is not the fault of the Patent Office, but is due almost entirely to the insistance of unscrupulous attorneys whose fees are staked upon the procuring of a patent, whether worthless or not, being frequently a matter of indifference to them, and sometimes upon the demands of clients who are impervious to advice or critiscism, until, as the possessors of useless patents, their ambition dies a natural death. There are, too, cases in which a patent that would not stand the test of a suit is really of advantage to the inventor, but the first-named cause is by far the most common.

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An idea seems to be entertained by many that the less a person is hampered by knowledge of a particular art the better his chances of being original, and the more likely he is to strike into a new line, and to capture a grand idea which, when harnessed and put to work, will develop into a tidal wave of prosperity, like the winning ticket in a lottery. Observation has shown that such inventors will rarely consent to a preliminary examination at any price, and that they are the most ready to assert that the examiner has failed to comprehend their invention.

The examiners are, as a class, exceedingly capable, but one thing should be remembered, which is, that they do not occupy the position of critics, and while it is often apparent to them that an application might be advantageously altered or more fully developed, still they can only act upon what is before them; they have nothing to do with what might be. That is mere speculation, and they are not in the position of investigators; they are simply there to deal with what *is*, and knowing more or less about all the patents in their particular class, an invention appears smaller to them than to a person unacquainted with the state of the art.

When it is remembered that, as a part of the result of the labors of these gentlemen, thousands of old and often absurd ideas are every year consigned to oblivion, instead of being spread upon the record, and that on reading the claims of a patent, if there is nothing more in it than some trifling combination, that fact at least will be at once apparent, thus saving the public in general much trouble and expense, the beauty and advantages of our system as compared with the systems of other nations, and the way in which our laws contrive to offer the maximum encouragement at the minimum public expense, will be better appreciated.

DISCUSSION.

Mr. FRANK L. POPE:—I do not know that I can add very much to what Mr. Jannus has so ably stated in his paper. The remarks which he makes in reference to the examiners in the Patent Office are very proper. Those gentlemen are subjected to much unjust criticism. I have practiced before them more or less for some fifteen years. I have almost invariably found them courteous, careful and honest in their work. They labor under the disadvantage of having so much work thrust upon them, so much to be done with an insufficient force, and an insufficiently paid force, that to every one familiar with the circumstances, as

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most of our solicitors and practitioners are, the only wonder is how the work is done as well and with as few mistakes, and as little injustice as is the case. We all feel that there might be a great many improvements made in the management of matters at the Patent Office; but the difficulty is in the lack of adequate legislation, not in the character of the examining force, for this is better than we might have any reason to expect we could get for the salaries which the government affords. Examiners are obliged to pass over many cases with an insufficient examination; to allow many patents which they feel certain contain nothing of novelty, and of which if they were allowed sufficient time they could undoubtedly find an anticipation. We often hear it said of patents which have no originality in them, that if they are good for nothing they will do nobody any harm; but as a matter of fact they are often taken up by unscrupulous speculators, and used to levy tribute upon deserving inventors who have worked out something of real value which they are endeavoring to bring before the public. A worthless patent, which apparently on its face covers the whole matter, is bought up and very often capitalists are thereby discouraged from aiding the real inventor. I think that the general subject is worthy of more attention than it has received, and that those who are disposed to criticise our patent system should be careful to examine the matter and see that their criticisms fall in the right place, which is really upon Congress.

Mr. E. P. THOMPSON:—There was one point in Mr. Jannus' paper in regard to modifications of inventions which I should like to refer to. A man strikes a good idea. He wants to get it patented. He finds that he cannot get an idea patented. Then he makes a rough sketch of it. He is told that that won't do. He goes to work, and at the expense of a good deal of mechanical genius, perhaps, tries to get up a working device, and then he finds that it will not work. Some other man comes along who takes up the idea. He makes a model that does work. The first thing, then, is the invention—the principal invention. After the first inventor has taken out a patent, scores of other inventors come along and take out patents on about the same thing. They are patents on the modifications. Now I think that the very best way in which an inventor can protect himself is to make as many modifications of his invention as possible before he proceeds to apply for a patent. For some time past I have thought on the subject as to whether there are any rules that an inventor may

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follow in order to make the modifications of a particular invention, say, for instance, the telephone. When that first came out it involved the principle of producing an undulatory current by means of a transmitter. The first inventor made one or two modifications to illustrate his invention. But why didn't he go to work and make twenty or thirty modifications? How is the inventor to go to work to produce the modifications? Let him study his invention and see what action is to be produced. One principle to be applied is to vary the resistance of the current. One way to do that is to vary the length of the conductor. That conductor may be a solid, a liquid, or a gas. Let him get up all the devices by which he can vary the length of a solid conductor; get up all the devices by which he can vary the temperature of a solid conductor; get up all the devices by which he can vary the density of a solid conductor; get up all the devices by which he can make or break the different parts of a solid conductor. Then he goes to the liquids and gets up all the modifications relating to liquids, and even goes so far as to introduce the principle of electrolytes and electrodes, varying in the size of the elctrodes, varying the heat produced in the electrolyte, which will, of course vary the resistance; varying all of these different things combined. Then he may go to work with the gas and vary the resistance of a gas raised to a higher temperature in a vacuum, or between the electrodes of a condenser, and then he combines a solid and a liquid so as to vary the resistance. All these modifications will produce the transmitter; and it seems to me that there are laws, principles and rules which exist, but have not been thoroughly worked out, whereby a person, having made an important invention, can follow these rules so as to make all the modifications, and in that way he will be better protected than by any law of the United States Patent Office.

Mr. F. L. Pope:—I would say in reference to the remarks of Mr. Thompson that in my experience with inventors, which has been considerable, I find that with very few exceptions their minds are apt to run in a groove. They make a particular invention, and then try to follow the advice Mr. Thompson has given us, and think of as many modifications of it as possible. I have known instances of their getting twenty or thirty modifications, and yet when you come to analyze these you will find they have more or less affinity to each other. They all have a certain relationship and resemblance. A man having a different order of

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mind is attracted to the subject, and he takes it from an entirely different point of view. He works out an entirely new set of adaptations of the same fundamental idea, producing the same result, but utterly unlike anything the first man could ever possibly have thought of. Take the instance of the telephone which Mr. Thompson alluded to. Professor Bell, in his invention of the telephone, produced his undulatory current by vibrating an armature in front of the pole of a magnet and thus inducing a magneto-current. Of course, he saw that that was not the only way of producing an undulatory current, and he said in his patent that it might be done in various ways, as by vibrating the two parts of the conductor in an imperfectly conducting liquid, and by vibrating the plates of the battery and various other methods, but he suggested no practical way of working on that plan. A host of other experimenters and inventors went to work on it, and among them they discovered that carbon was the substance that would do it best. That was discovered by experimentation, not by reasoning; perhaps by reasoning and then trying; but it is a rusult that certainly would have been difficult to get at by the particular process of reasoning which Mr. Thompson suggests. At the same time it is very clear that his method would in many classes of inventions serve to cover the whole ground. I merely mention the case of the telephone as one in which I hardly think the complete and perfected result would have been brought about in the mind of one single person.

Mr. JANNUS:—I would like to interject a remark or two myself. In preparing this paper, of course, it has been impossible to go into the details of any one particular branch; but I think that the subject of modifications is fully as important as anything else that the attorney or the inventor has to consider. Now, it very often happens that an inventor will embody his idea in a device. He will have an application prepared and probably receive his patent, and some time afterward he will discover that somebody is trying to evade his patent, and has done something that he might just as well have done himself, and that by reason of carelessness or an insufficient appreciation of the contract that he was entering into with the public, he had not done it himself, or stated that he contemplated doing so, and how; and then is the time the inventor tries to make his attorney responsible for anything that is left out, or rather might have been included, if the inventor had given the matter careful attention when the application was being

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prepared. I have a case in mind at the present time, in which the papers were sent to the attorney three times by the inventor and three times returned to the inventor by the attorney. Each time the attorney told the inventor: "You have shown so much and you have suggested so much more; now you have got to do your own inventing. If you choose to bring that in, give us a sketch; if not, understand that it is going to be left out." Finally the case went into the office after a third revision, and was allowed without an objection. There was something entirely new about it. There was such a difference between the first and second and third sheets of those drawings that they could each one have been separately patented if they had been presented by three separate men and specifically claimed. That is why I think that special prominence ought always to be given to that branch of the subject.

Mr. T. D. STETSON:—I labor under the disadvantage of not having heard all the paper, but the matter has been referred to since so clearly that I can say something in regard to the matter of modification. The history given by the gentleman who read the paper of the case going backward and forward several times is an interesting one. That inventor was fortunate in having an agent who took that amount of pains, and the agent was fortunate in having a client who complied with his wishes so promptly. It was a case of a good job due to both of them. In many cases the inventor is so anxious to cover all the ground that he does not give a specific and exact description of anything. One of the things we want to do in all these cases is to make one specific description, and, by rights, perhaps, it ought to be the best form, but that doesn't matter so much. You may select the simplest one; or sometimes I am fond of selecting the most complex, the most *outre*, the most *bizarre*, the one that has the most heads and horns to it. I have a kind of sterreotyped form of expression that I work into almost all specifications saying that modifications may be made in nearly all points without sacrificing the advantages of the invention, and then go on and enumerate a few. In this matter of modifications sometimes this state of things arises which is of interest—the main, bottom principle has already been covered by some absurd thing which would not work, and we find the art already advanced to such a stage that we cannot make the broad, sweeping claim we want to. In fact, it almost always seems so, and we have got nothing left but modification, though there will be modifications of the modifications, and so on. In one case I had

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a steam pump matter—a pulsometer. The bottom thing had been done by somebody who made a poor one. Then came a man who made a sensible one, the one that has been used all over the world —Hall. Mr. Pope has explained very nicely how there will generally be a family relationship with these different things if they all come from the same man. But a man that is ingenious can make a good lot of modifications. I was the agent who probably ever took out the most patents on one thing on the same day—twenty-nine. On the 30th of May, 1882, twenty-nine patents were issued to one man on a matter of steam pumps, and the man tried with considerable success to cover all the modifications that could be made that were good for anything, except the one that had been specifically stated in the original man's patent. Now if the original patent has got a particular claim, and that claim was drawn by skillful hands, and if the proper amount of help had been given by the inventor to the attorney and the proper amount of help back again, the original claim ought to have been big enough to cover them all.

We have changed the law and the practice a good deal with regard to obtaining reissues. When the modifications had been made by other people or by ourselves, we would go to work and reissue our patents. The Supreme Court has put an end to that. In a series of cases they have decided that if a man has got his patent wrong he ought to find it out right away. It has been intimated in some of the decisions that two years is enough. Practically we might say that the man ought to find it out within two years and apply for his reissue. It amounts to this, that for two years the inventor has the privilege of monopolizing all the improvements that come up after it. Some foreign countries provide for that formally by law. Austria tries to give nobody else a patent for a modification, or branch, or ramification, or improvement on the original idea, for a year—a nice thing in practice. We have got something like it that gives the inventor two years, which is better yet.

Mr. F. L. Pope:—I should like to call the attention of Mr. Stetson to one of the decisions referred to by Mr. Jannus, a recent decision of the Supreme Court, and I hope I may be pardoned for mentioning it, as the suit arose on a patent of my own for which I drew the specification myself. It was on this very question of modifications. It was the case of the railway signal, The patent was for a particular system of circuits for operating

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signals automatically by the movement of a train along the line of the road. Now everything about the general system was old. There had been innumerable forms of signals worked by electro-magnets and batteries, and having the circuits closed in some manner by the train moving along the track; the idea being that as the train progressed from one signal station to another, the signals would be exhibited in orderly succession behind the train, and the track thus be kept blocked in the face of a succeeding train. The most common plan had been to have one signal for each section, with its own battery, its own circuit-closer, and its own separate electric circuit. The improvement which was intended to be patented was a system of circuits by which one battery was made to do the work of the several individual batteries which had before been scattered all along the road. This battery was placed at some convenient point and two battery wires were carried along the road, and the circuit-closers, signals, and the like were connected with them, so that any particular signal was operated through those wires. Now the form of circuit-closer described in the patent, which was a very old one, was a short section of insulated track-rails brought into connection with each other through the locomotive, which served to close the circuit and operate the proper signal. That was one form of circuit-closer that had been long in use; and of course there were other forms, equally well known, in which a pedal was depressed by the wheel of the train, being fitted with a key at the other end. Another method was to put a circuit-closer underneath the rail, where the deflection of the rail would press the circuit closer down, and in that way operate the signal. All these devices were very old, and there were probably anywhere from ten to fifty of each kind. Now the patent expressly stated in its specification that it was not confined to any particular species of circuit-closer. The patent said the circuit might be closed by a hand circuit-closer, for that matter. The novelty consisted in the specific arrangement of *circuits* to work all the signals from one battery. But the Supreme Court held that because the defendants did not use the particular kind of circuit-closer, that is an insulated rail (instead of which they used a key which was operated by the depression of a lever by the wheel,) they did not infringe. Now that might have been true if that method of closing the circuit had never been known before; but in fact it was the oldest form in existence. So that we see in that case the description of the preferred form and the

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statement that other well-known forms might be used in place of it, did not answer the purpose.

Mr. THOMPSON:—I do not know exactly whether I made the main point clear about these modifications; but it seems clear to me, and I want to make it clear to you. In any department that you take up, you find the rules, the laws that exist, and after they are discovered they are applied. A long time ago perhaps not more than one man out of a million would have been able to paint a picture that looked like the object it was intended to represent. As time went by somebody noticed that when you look at an object at a distance it has a certain appearance, and in order to represent that on the canvas, it is not necessary to go into all the details just as they appear to the eye; but there are certain optical deceptions which you must reproduce. It is not necessary to go through all the different departments; but it is the same, I think, in a great many departments where rules are established, and men learn to become artists or professors in any department by studying these rules and the principles underlying the rules. Now that method has not come to perfection yet in the department of invention; the process of invention has not yet become a science. The examiners sometimes say that a thing shows no "inventive genius." To me the term "inventive genius" has no meaning when used in reference to derived inventions or modifications. For instance, I say to a man: "Here is a carbon filament shaped like a figure 8; if you make that carbon filament in a different shape you can get a patent on it." Now the man who makes it in another shape may not have any inventive genius. During the past year two patents have been granted, one on a kind of double figure 8 and another on a spiral—absolutely on the *form* of the carbon filament. Some people may say that is of no value. They do not know, until they really study the thing, whether the invention is valuable or not. So another man would go to work and make carbon filaments of all the geometrical forms you could think of. Now if the first inventor had the wit to get a patent on the form, he could have included all the forms imaginable. I speak of these things, seeing that there are several gentlemen here interested in this subject, both as inventors and as attorneys. When they see any invention come out, if inventors will notice what rule they can follow in order to apply that same principle of invention in some other department, the number of inventions will be multiplied, and by multiplying the number of inventions the progress of civilization is furthered.

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Mr. F. L. Pope:—I do not wish for a moment to be thought to say anything in disparagement of Mr. Thompson's plan, for I think the systematic study of all these things is of the utmost value, and that inventors' work would be a thousand times better done if they would reduce their thoughts to some system and follow it out in a logical manner; but still I regard it as a mistake to suppose that any system of that kind carried out to however great perfection, would necessarily develop all that there is in any one line of invention. It seems to me that the matter of invention does not differ materially in that respect from painting pictures or composing music. Every artist does a great deal better work for having a systematic, thorough course of training in all the principles of the art. It is the same in music and it is the same way in many other things. But after all that is not the way in which great composers, great artists, and great inventors accomplish their work. It is most valuable assistance to them and most neccessary assistance, but still it is not everything; there is some inspiration beyond that. Mr. Thompson does not understand that there is such a thing as "genius" in these matters. I think there is a little. But, as I say, I heartily concur in everything he has said about the importance of systematic study, and I think Mr. Thompson is entitled to great credit for being the first one, so far as I know, to systematically develop such a plan of investigation. I believe the work which Mr. Thompson has done will be recognized in all future time as of very great importance; but, as I say, I don't think it quite covers the whole ground.

Mr. Thompson:—I wish to correct a misapprehension of what I said in regard to inventive genius. There is inventive genius, in my opinion, in the first conception, but in respect to the modifications of that invention I think the work can be followed out by rule.

Mr. E. P. Roberts:—If I want to get up any little thing I say to my man and he is one whom I can trust thoroughly, "I want to do so and so; you think it over, and put down on paper what you think about it." I put down on paper what I think of it. He shows his plan to me, and I show him mine already drawn out, and we compare them together, and they may both have points that may be worked together, and in that way we often cover points that neither of us would have thought of independently. I think inventors as a general thing are not trusting men. If they could trust other men and work together more than they do, I think it would be advantageous.

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Mr. T. C. MARTIN :—It will be remembered by Mr. Jannus that at our meeting in May of last year a resolution was adopted, "That the chair appoint a committee of three, who shall take such action as they may deem proper, with a view to calling the special attention of Congress to the needs of the Patent Office, especially in regard to the class of electricity."

I may say that there was a good deal of contemplated patent legislation last year, and in view of that fact the Council held its hands. It appears that some action might properly be taken this year. As to the needs of the Patent Office in regard to electricity, I would like to call attention to a paragraph in our first volume of Transactions, from the valuable paper read by Mr. Kintner. He asks the question: "Now, gentlemen, what do you think of a bureau of scientific experts upon mechanical, electrical and chemical technics, without any mechanical workshop, without any electrical apparatus, and with a laboratory having a total valuation of less than $500." That statement has a very direct bearing on this question of protection of electrical inventions, and I think that the Society might strengthen the hands of the Council by asking them to put into force the resolution passed at the meeting last May. There is one point on which I would like to ask Mr. Jannus a question, relating to that same matter. Mr. Jannus here says: "The Patent Office is responsible to nobody and guarantees nothing." Are we to accept that, gentlemen, as it stands? Are the inventors to understand that? Are the patent lawyers of the country to understand it? There are now over six thousand electrical inventions patented in this country. It seems to me that the number is not likely to be very largely added to if it is to go on record without any modification or explanation that the Patent Office guarantees nothing and is responsible to nobody. It seems to me also it is not of much use for this Society to seek to bring about a reform of the Patent Office if it guarantees nothing and is responsible to nobody.

Mr. JANNUS :—That is an exceedingly pertinent question, and I am glad that it has been asked. I say here that "the Patent Office is responsible to nobody and guarantees nothing." I stick to just exactly what I said there. The Patent Office is a sort of an investgating bureau to which an application is submitted, and the duties performed there are simply to examine that application, and if they can find anything to anticipate, to reject it on those references. After which the applicant may amend his claims,

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and when he gets his claims down to a point that is satisfactory to the bureau, the patent is issued. Of course, the courts are ultimately the tribunals before which the question is settled. If the Patent Office grants an inventor too much, it is cut down. If it grants too little, the courts have said, "You ought not to have accepted the patent; you ought to have insisted on more." It seems rather a bold statement to say it is responsible to nobody, and guarantees nothing, but it is literally true. Those gentlemen are there to act on what is before them. There is no penalty whatever for the failure, on the part of the examiner, to cite an exact reference, even if he has it in his portfolio. But there are many classes to-day in which the art is not thoroughly represented in the Patent Office, and consequently it is an impossibility for the examiner to know what has transpired. Patents are granted every day for things that are old, but the Patent Office does not know it. Now, what are their sources of information? Patents that have been granted, foreign patents, publications, and, in some instances, a few catalogues from leading manufacturers. I might suggest that, in the class of velocipedes, for example, the Patent Office is behind the time. I do not think that the examiner in that class has in his room, at the present day, well known catalogues that show ten times more than any patents that have ever been published, and you will easily see how it is possible for them to overlook pertinent references without intending to do so. If a patent is declared invalid to-morrow, the examiner does not suffer in any way. He is sorry, perhaps, but he does not suffer. There is no penalty attached. He does not lose his salary or his position; and I made that statement to call your attention to the fact that it is for the individual, through counsel, or by himself, to thoroughly investigate the matter, and be just as sure as he can make himself that what he gets he is entitled to; and that what he is entitled to has been put in the best possible form; because, if those two circumstances concur, the result is a patent that will be sustained by the courts to the end of its term, and which nothing can endanger; and it is only that sort of patent that is able to withstand the efforts of infringers.

The Chairman (Mr. SYDNEY F. SHELBOURNE):—I observe that Mr. Jannus uses the terms "responsible" and "guarantee" in their legal sense. It would be impossible to bring a suit against the Commissioner of Patents or the Examiner for making an error.

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Mr. MARTIN:—That is exactly the point I wish to have explained. It might appear to the public that we had calmly accepted the statement that it was the case, and I would not like to have it go out in that way.

Mr. JANNUS:—I am sorry I did not answer the question; I thought I had, but it seems I did not. From the Commissioner down, the Patent Office officials are judicial officers. Their acts are those of discretion largely. They use their judgment and they decide. They are not responsible legally to any one; if they make a mistake you can bring no suit against them; you can recover nothing from them. There is, however, one method providing for rectifying mistakes as soon as may be, which is this: If a patent has been granted to the wrong person, and the right person comes in subsequently and makes the fact apparent to the Patent Office, they will grant him a patent also, so that while they cannot cancel a patent once granted, they will grant a second one, and it is expected and assumed that the evidence brought forward to justify them in granting the second patent will be sufficient to substantiate the right of the latter applicant. But the final decision of the question goes before the court, and is there decided, and there only.

Mr. POPE:—I would like to ask Mr. Jannus whether some measures have not been taken within the last year, looking to the procuring of a laboratory for the Patent Office? I had some conversation with the late Commissioner, Mr. Marble, at one time within the past year, and I gathered from what he said that some movement was on foot which would probably result in the providing of a considerable amount of apparatus for the use of the Office. Perhaps Mr. Jannus can tell us if anything has been done which might render action on our part, with regard to this resolution, superfluous.

Mr. JANNUS:—There has been discussion on the subject. It has been considerably agitated; but as a matter of fact, the Patent Office is almost in the same condition as it was before, so far as we are concerned. There is no chemical or electrical laboratory there at all. There have been a few incandescent lamps put into the building, and of course the apparatus necessary to operate them is accessible for the instruction of the new men. That is all. The Commissioner, however, has had his attention called to it. Mr. Kintner has made continued efforts in that direction, and it is really hoped that the next Congress will do something about it.

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I think that a memorial or some such step might be taken to call the attention of the Committee on Patents to the subject, which would be of some advantage. They propose to have a building. They have plans of a shed to use as a laboratory, but nothing whatever has been done.

THE CHAIRMAN:—At our last meeting the following resolution was passed: "Resolved, that the Chair appoint a committee of three, who shall take such action as they may deem proper, with a view to calling the special attention to Congress of the needs of the Patent Office, especially in regard to the class of electricity." It does not appear that that committee was appointed, and if some member will offer some motion with reference to taking action on that subject, it may be referred to the Council and assume shape and activity from that source.

Mr. JANNUS:—To bring the question before the meeting I move that the matter be referred to the Council, with the suggestion that they appoint a committee to present the matter to Congress in such form as may seem to them best. Motion carried.

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A paper read before the American Institute of Electrical Engineers, May 20, 1885.

COST OF MINE LIGHTING.

BY F. P. MILLS, STAMBAUGH, MICH.

THE plant was set up and running at the Cleveland iron mine Ishpeming, Mich., May 10th, 1880.

The machine employed was a No. 7 Brush dynamo, with old style armature core, and lights of 2,000 candle power each.

For the underground workings was used a so-called dye house, single carbon lamp. The connections across the top of the lamp being filled in with tar; rubber gaskets being placed between the case and side plates. The surface lamps were of the ordinary double carbon pattern.

The dynamo on stone foundation, topped with a shellacked hard wood plank, was placed in their No. 1 engine house; and three distinct loops, all of No. 8 copper wire, were run from there.

The number one circuit comprised all the lamps underground in No. 3 pit, and was about 3,000 feet long.

Number two circuit took in all the lamps on surface, they being placed at the various pockets and engine houses, and was about 4,600 feet long; while number three circuit ran into the incline pit, a distance there and back to dynamo of 6,000 feet.

A continuous ringing bell, permanently connected to a Leclanché cup; and with an outside coil of heavy wire traversed by the light current, serves to call attention to a break in the line.

In such an event the broken wire was cut out by a short circuiting switch, one being connected with each loop, and thrown in again upon the repairs being made.

The wires were run wholly upon glass insulators. Underground, where the brackets could not be spiked to stull timbers or wooden pockets, they were run to some iron ore pillar, or to the walls of the pit; and where neither of these could be reached, the wires were suspended from the roof or hanging wall. When run to pillars, or walls of the pit, the brackets were bolted to an iron cramp, having a suitable number of iron cross arms.

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A split end, fitted with a wedge, served to securely fasten the cramps in a hole drilled into the ore or rock. In the mine the lamps were suspended by a rope, running through a sheave attached to an eye cramp let into the roof. The other end of the rope was tied to any convenient piece of ore, rail or timber, as the case might be.

The lamps were always taken down out of the way at each blast, the switch-boards being pulled up close to the roof, to get them as much out of danger as possible, though this did not prevent them from being occasionally smashed.

The surface lamps were suspended in the usual way. The wires underground hung slack between the insulators, they proving less liable to be broken that way.

They could not, however, be prevented from being cut by the flying pieces of ore and rock in spite of all possible care, and every day a number of splices in each pit had to be made.

Lengths of wire would often have to be renewed entire, for the reason of their having been hit so many times, and containing so many splices.

There was used a 10 by 20 inch variable cut-off engine belted direct to the dynamo.

A stationary bricked-in boiler, 5 by 16 feet with 81 3-inch tubes, supplied the steam, the boiler being shut off from the hoisting engine and used only for lighting purposes.

Both wood and coal were used, though for each separate month it was all coal or all wood.

The engineer's time was not charged, as he could easily attend to the dynamo and engine while doing his other work, neither did the light stand the expense of firemen, as it cost no more to fire than when simply doing the hoisting, no extra wages being paid. The only labor cost was that of one man upon each shift, whose business it was to renew carbons, mend lamps, and keep the wires in repair. The plant worked 20 hours out of the 24 every day, except Sundays.

With wood at $2.50 per cord, it cost for fuel for the three months of September, October and November, in all 8,291 hours, an average of 3.0907 cents per hour per lamp, or .01233 cords of wood per hour per lamp. For December month, with soft coal carefully weighed and charged at $5.00 per ton, the 4,676 hours

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run cost 3.462 cents per hour per lamp, or 13.85 pounds of coal per hour per lamp. The above is simply the fuel cost, the complete cost, in detail, is as follows:

OPERATING EXPENSES.

MONTH OF DECEMBER, 1880.

Costs common to all Lamps.

LAMPS.	COAL.				OIL.				ATTENDANCE.		
	Tons.	Cost.	Per Hour per Lamp.		Gallons.	Cost.	Per Hour per Lamp.		Days	cost.	
			P'nds.	Cost.			Gallons.	Cost.		Am'nt.	Per Hour per Lamp.
All Lamps.	32 760	161 90	13.85	.03462	12.	12 00	.00256	.00256	50	100 00	.02138

SPECIAL COSTS.

LOCATION OF LAMPS.	CARBONS.			COPPER WIRE.			ROPE.			SUPPLIES COST.	
	Number.	Per Hour per Lamp.		Feet.	Per Hour per Lamp.		Feet.	Per Hour per Lamp.		A'mt	Per Hour per Lamp.
		Inch.	Cost.		Feet.	Cost.		Feet.	Cost.		
No. 1 Engine House	75	1.8127	.01057								
No. 3 Dock - -	44	2.4082	.01404								
Incline Dock -	4	2.5263	.01473								
No. 3 Engine House	42	1.7439	.01017								
Total surface	165	1.9341	.01128							1 40	.00136
Incline Pit - - -	335	2.0727	.01209	276	.14230	.00593	75	.03867	.00049	2 30	.00118
No. 3 Pit - - -	343	2.4035	.01402	216	.12613	.00525	100	.05839	.00074	4 09	.00239
Grand total -	843	2.1638	.01262	492	.10522	.00438	175	.03742	.00048	7 79	.00166

RECAPITULATION.

LOCATION OF LAMPS.	LAMPS BURNING.		TIME.	TOTAL COST.	COST PER HOUR PER LAMP.		REMARKS.
	Day.	Night.	Hours. min.		without Attendance.	with	
No. 1 Engine House	1	1	496.30	35.02	.04922	.07060	Price of Carbons .07 each.
No. 3 Dock - -		1	219.15	16.21	.05263	.07402	" Coal - 5.00 per ton
Incline Dock - -			19	1.40	.05230	.07368	" Oil - - 1.00 " gal.
No. 3 Engine House		1	289	20.27	.04875	.07014	" Cop. Wire .50 " pd.
							" Rope - .16 " "
Total surface -	1	3	1,023.45	72.90	.04980	.07119	" Supplies - at cost.
							" Attendance, $2.00 per day.
Incline Pit - -	4	4	1,939.30	151.82	.05687	.07826	
No. 3 Pit - - -	5	5	1,712.30	138.72	.05964	.08103	
Grand total -	10	12	4,675.45	363.44	.05634	.07772	

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The cost for four months, hours burning, and cost per hour per lamp is as follows:

OPERATING EXPENSES FOR FOUR MONTHS, ENDING DECEMBER, 1880.

MONTH OF	TIME.	COST.		REMARKS.
	hours, min.	Amount.	Per Hour per Lamp.	
September	1,668.10	122.86	.073657	This includes everything but the expense of firemen and engineers who attend to other work and do this without extra cost.
October -	3,353.20	239.37	.071384	
November	3,270.20	251.81	.077000	
December	4,675.45	363.44	.077724	
Total -	12,967.35	977.48	.075382	

It will be noticed, from these cost statements, that the consumption of carbons was greater in the exposed surface lamps, than in those in the engine houses, and but a little more than those underground.

The cost of lights, in the hoisting engine houses, was less than with kerosene, as with the latter one lamp would be put over each drum, in addition to lights for the engine.

Upon the docks there was no comparison with oil, as the electric lamp threw a light that enabled the cars to be readily handled, and of such assistance to the ore sorters in the way of showing the true colors, that they could not be dispensed with.

In the mine they were employed at all the big stopes, and especially where much filling or ore sorting was going on.

Although many miners' lamps had still to be used, it was considered economy, even at an additional expense, to run the lights to admit of a better supervision of the operations; more work done, and cleaner ore.

Another use to which the lamps were sometimes put, was to reverse them in the line, and examine the roof by the strong upward light thus thrown.

The plant is still running without material alteration, excepting the mine circuits, which have to be advanced as the work progresses.

Following are figures the chief engineer has just sent, showing their present fuel consumption, which indicates an improvement

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on the old run. With seven lamps burning, the engine indicated 11.73 horse power, with a consumption of 36.79 pounds water, and 4.9 pounds coal per horse power per hour. This is adding 20 per cent. of water shown for indicated horse power, by the card, for loss by condensation, and making a moderate allowance for boiler evaporation of 7.5 pounds water per pound of coal. This gives 1.675 horse power per light, and 8.211 pounds of coal per hour per lamp. With more lights, or a larger plant, the result would show still better on account of less friction, a longer cut-off, with a consequent higher effective pressure, and less condensation.

DISCUSSION.

The CHAIRMAN: Discussion on this paper is now in order. I presume there are gentlemen present who are experts in arc lighting. I will call upon Mr. E. P. Roberts to give us his views.

Mr. ROBERTS: I would like to ask what kind of coal. I heard $5.00 a ton for soft coal, and I thought I heard before that $2.50.

Mr. MARTIN: $2.50 for wood.

Mr. ROBERTS: Then I misunderstood. Does it say whether it is lump, slack, or what?

Mr. MARTIN: It says here: "Soft coal carefully weighed and charged at $5.00 per ton.

The CHAIRMAN: I suppose that Mr. Roberts is acquainted with the use of storage batteries for lighting?

Mr. ROBERTS: We have no mine lights at present.

Mr. MARTIN: There is one point there that seems to me to call for a little remark.—"They (the wires) could not, however, be prevented from being cut by the flying pieces of ore and rock in spite of all possible care, and every day a number of splices in each pit had to be made. Lengths of wire would often have to be renewed entire, for the reason of their having been hit so many times, and containing so many splices." If I may be permitted to refer to the *Electrical World* of January 24th, there was an article by Mr. C. E. Reynolds, who had done some lighting in tunneling in the Mantiqueira mountains in Brazil. He says with regard to the running of the wires through the mine: "The wires were fixed against the sides of the tunnel by wooden plugs driven into holes bored for them. At first these were simply laid along the tunnel without any covering, but I soon found that it would

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never do to leave them bare. The pieces of rock flying about from the frequent blasting soon made havoc both with the wires and with the lamps. Some means had to be devised to protect them. The wires I placed in a casing of thick boards right through the tunnel with a lid that could be easily opened when I wanted to get at the wires.

Mr. ROBERTS: The figure given as to the cost per hour—does that include repairs on wires, for it seemed to me pretty high?

Mr. MARTIN: The remark is, "This includes everything but the expense of firemen and engineers who attend to other work and do this without extra cost." It is a comprehensive cost statement, I take it. This paper, I might state, refers to arc lighting under ground. If any gentleman would favor us with remarks on incandescent lighting to the same purpose it would be interesting.

The CHAIRMAN: I assume that for incandescent lighting storage batteries may be in use. I am not aware that they are. I think, perhaps, the branch of the subject relating to storage batteries and incandescent lighting might be discussed to advantage, if there is anything to be said on that subject.

Mr. THOMPSON: Would not that subject come more properly under the head of the paper on storage batteries for commercial purposes?

The CHAIRMAN: Has Mr. J. F. Kelly any views on this subject?

Mr. KELLY: I have nothing to say that would interest the Society sir, in regard to that.

The Chairman: If there is nothing further to be said, the discussion on that paper is closed and the next paper will be read by Mr. Edward P. Thompson, mechanical engineer on the Electric Arc Lamp Frictional Clutch.

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Read before the American Institute of Electrical Engineers, May 20, 1885.

THE ELECTRIC ARC LAMP FRICTIONAL CLUTCH.

BY EDWARD P. THOMPSON, M. E.

The object of this paper is two-fold—to bring before the society a new invention, of which the writer is not the inventor, for the purpose of soliciting from electricians their criticisms and opinions. The opinion of the writer, in the first place, obtained from his investigation of existing patents, of models of the lamp, and of the important modifications capable of being made, is that the patent is valid, the invention is ingenious, the device is simple, and the result is a non-vibrating movement of the electrode and an absence of dash-pots and other means of compensating for sudden variations of current.

The second object is to make the members have the same opinion. Assuming this to be a dfficult task, he desires, as follows, to make an analytical investigation of the development of the frictional clutch.

The well-known trick of a ball, and string passing through a crooked hole in the ball, whereby the loosening and tightening of the string cause the ball to fall and to stop respectively, operates upon the same principle as the frictional clutch, and the principle may therefore be defined as a clutch for a carbon holder, consisting of a device whereby a variation of pressure upon the carbon holder produces a variation of motion of the electrode. Any device falling under this definition is a frictional clutch.

Any one making a frictional clutch will infringe no one's patent so long as he makes a clutch different from any other clutch in every detail; for the patent granted to Slater & Watson, of London, in 1852, No. 212 (English), includes two superposed clutches which are simultaneously the armatures of electro-magnets, and through both of which the carbon holder freely falls when the armatures are horizontal, but ceases to move when the armatures are inclined, exactly in the manner of action of the ring clutch in the Brush lamp. The patent referred to, being dated thirty-three years ago, has expired. It is fully described in Dredge's "Electric Illumination," page 387, and in the appendix, page xxxvi., as a carbon holder passing through an eye in a lever actuated by an electro-magnet.

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The above definition of a frictional clutch may be analyzed and considered as a problem for the purpose of arriving at the conditions to be fulfilled, when and where they should be fulfilled, and in what manner.

In the steam engine, variation of pressure was formerly obtained in the cylinder, and is at the present time, in some instances, by means of the movements of a throttle-valve located at a distance from the cylinder. In the improved forms of engines the device for varying the pressure is located in the cylinder itself, and the slide valve is employed both as a means of admitting the steam and as a means of regulating the amount admitted, and in all departments of industry it is advantageous to locate a regulating device as closely as possible to that which needs the regulation. Therefore, is it not necessary that in an arc lamp frictional clutch, all the regulation of pressure should take place at the carbon holder itself, and not by means of dash-pots, springs, etc., located at ends of levers which are endowed with the unremovable property of inertia and weight? Evidently it is preferable.

The variation of pressure in the electrodes of telephone transmitters all takes place, in the improved instruments, within the limits of constant and complete contact. Upon small variations of current in the case of the ordinary ring clutch, the ring and the carbon holders are not always in contact, especially if the variations of current are very great, and more especially if the dash-pot is not attached. The consequence is that the carbon holder falls a greater distance and with greater suddenness, and stops also with a greater suddenness than if the friction were not entirely removed.

Some have said that the unsteadiness of the arc lamp is due to the poor quality of the carbon; others, to the defects in the generator; others, to the cutting in and out of other arc lamps; others, to the poor construction of the system in general and others, to all these combined: while they seem to think that the clutch has reached its perfection and that there is nothing to be said against it: whereas, according to the definition, a clutch could certainly be made which would produce alternate darkness and brightness at almost any rate.

We may safely say that the steadiness depends upon the clutch more than upon anything else.

The intensity of the light and heat depends upon the length of the arc. Therefore, the intensity of the light due to incandescence

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of the electrodes and to their combustion depends upon the length of the arc.

The length of the arc depends upon the electromotive force, upon the shape of the electrodes, and upon the distance apart of the electrodes; or the arc may be kept constant in length by varying the distance between the electrodes every time the other named variables change; in short, the steadiness of the light or length of the arc depends upon the quickness and definiteness with which the distance between the electrodes changes after the other variables have changed, and upon the steadiness of movement of the electrodes.

Coming now to the action of the ring clutch and all its modified forms and adjuncts, let its operation be analyzed thus, with as little reference as possible to any other part of the lamp. When the ring is horizontal, the carrier of the carbon electrode is free to fall. When it is inclined at its maximum, the carrier is retained in a fixed position. At a certain point of inclination, the least increase or decrease of inclination will cause the carrier to fall or to be retained from falling. If the increment or decrement of inclination be infinitesimal, the carrier and clutch are still in contact, and the friction existing between the two surfaces diminishes the velocity as it tends to increase, and thereby gives the holder a uniform motion through an infinitesimal distance; but the increments and decrements of inclination of the ring are not infinitesimal, and therefore the ring and carrier are not in contact when the decrements of inclination occur, although the period of non-contact is very short. The consequence is that the velocity of the carrier increases as the square of the distance during the time that the ring and carrier are out of contact. To take the place of this lack of the retarding effect of friction, inventors have supplied a dash-pot whose piston is connected directly or indirectly with the ring. This is a help, undoubtedly, and its efficiency would be very marked were the individual movements of the carriers of any considerable degree; but as they are all within a distance of a very small fraction of an inch, such as a tenth or a hundredth, the piston scarcely acquires any motion at all, and especially not till after the carrier has been checked by an increment of inclination of the ring, on account of the inertia of the parts and lack of definite motion at the connecting joints.

As a means of closing doors noiselessly and in steam engines, the dash-pot is very desirable and effective for the purpose in-

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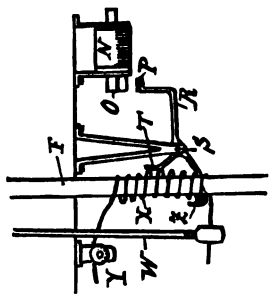
tended, and is adapted in all cases where any considerable extent of motion takes place; but for an arc lamp clutch it is theoretically and practically a non success.

Several patents have also been taken out involving a spring



NEW ARC LAMP CLUTCH.

attached to the ring, so that the motion of the carrier would be retarded, when the ring is inclined. This may be called an improvement from some stand points, but the fact still remains that the carrier and ring, even with the spring attachment, do not remain in contact, and therefore the movements of the latter, being vibratory, the movements of the former are vibratory also, and not only vibratory, but jerky, as familiar to all versed in the art.

Waterhouse and Loomis have introduced further improvements by having two ring clutches, the former inventor supplying dash-pots and springs and locating the two rings at a distance from each other; while Loomis's patent locates the one ring upon the other with a spring between the two, the idea in each being to obtain a steadier motion by such an arrangement that the primary clutch is assisted by a secondary clutch, producing a combined and more effective result.

However, in all the improved forms thus far mentioned, and in numerous other patents acting on the principle of the ring clutch, the motion of the latter is abruptly intermittent and, therefore, that of the carrier is abruptly intermittent also. A clutch to be perfect, practically and theoretically, should operate to produce a continuous increase or decrease of pressure upon the carrier, and the piece producing this pressure should always be in contact with the carrier; *i. e.*, the pressure should never be zero, neither should it be so far diminished for maximum movements of the ring that the carrier has an accelerating motion.

We have before us a clutch invented by Mr. Jean A. Wetmore

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of this city. It combines within itself all the qualities and fulfills all the conditions required.

Its true value will be appreciated upon inspection of its construction and operation. As seen, it consists of a cylindrical coil spring through which passes the carbon carrier. By certain manipulations of the spring, the carrier may be regulated in its movements with the utmost nicety. If the spring is bent laterally, the carrier is lifted. If the spring is partially straightened again, the carrier is subjected to less pressure, and consequently its own weight causes it to move downward, not with an accelerated, but uniform motion, because the coil spring, tending to straighten itself, constantly presses against the carrier. It may be manipulated by the hand as easily as a ring clutch by electro-magnets, showing that its good results are not dependent upon the delicacy of action of the operating force. Accordingly, when operated by electro-magnets in the main and shunt circuits, the carrier is regulated so perfectly that the light is almost as steady as that of an incandescent lamp.

This clutch may truly be said to act by causing a variation of pressure upon the carrier. It may be operated effectually by the separate action of the shunt and main magnets, or by that of both, as in most ring-clutch lamps. The application of both magnets to its action is as simple as in the coil spring itself, and is accomplished by arranging the main magnet to *bend* the coil by a lateral pull upon its lower end, and the shunt magnet to *straighten* the coil by means of a forked lever, each end of which acts upon the opposite ends of the coil spring respectively and in opposite directions. There are several modifications adapted to be applied to cause the clutch to act, and the general mechanism may be the same as, or different from that of any other lamp. Mr. Wetmore has shown as much genius and simplicity in the details of construction of the whole lamp as in that of the clutch itself.

When the main and shunt magnets are both employed to operate the clutch, the arrangement of the levers is as shown in the drawing.

F shows the carbon holder, and the helical line shows the clutch, while the main magnet operates the end of the coil, and while the other end is fixed to the support *Y*. The shunt magnet operates the lever *R*, which is forked by the branches *T* and *Z*, the two arms being adapted to straighten the spring, while the main magnet is adapted to bend the spring, and thereby retain or lift the

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carbon holder, according to the amount of movement upward of the lower end of the coil spring.

DISCUSSION.

Mr. THOMPSON:—Thirty years ago Lacassagne and Thiers invented the differential magnet applied to the arc lamp, and it is the preferable form to apply with any clutch. The main magnet is modeled to bend the spring laterally. The shunt magnet acts on opposite ends to straighten the spring. There is no great movement necessary; it will take place even in a smaller distance than with the ring-clutch.

The CHAIRMAN (Mr. SYDNEY F. SHELBOURNE):—It seems to your chairman, gentlemen that this matter involves a fundamental principle in the proper operation of arc lamps. I recollect three years ago being in Montreal, when the matter of arc lighting was considerably newer than it is now. They endeavored to introduce arc lamps in the dining-room of the hotel where I was stopping; but, suddenly, the lights went out, and darkness reigned, and they had to resort to gas. I also have noticed, in the past two or three years, the operation of the cluster lamps in Madison Square, and latterly it seems to me that they have operated much more perfectly than they did two years and a half ago. I think this subject is fertile of discussion and observation, and I should be very glad to hear from members present.

Mr. J. F. KELLY—I understood Mr. Thompson to say that what would occur in large movements would certainly occur in small movements, and I think I understood him to say, shortly before, that what would occur in large movements, with the dash-pots, would not occur in small movements. Is there not some inconsistency there?

Mr. THOMPSON:—I mentioned, and intended to keep distinct, three classes of movements. One is infinitesimal, the second are small movements, and the third are great movements, and all those take place in the action of an arc lamp. You can conceive or a solenoid and its core where variations of current will cause that core to vibrate. In the telephone, the movements can be called practically infinitesimal. Then we speak of small movements where we would vary the currents so as to produce movements, but you could not see them. The latter would be thousands of times larger than those produced by an undulatory telephonic current, and yet they would be so small that you could

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not see the movements. Then the other class of movements are those that are visible. All these movements occur in ordinary arc lamps. The dash-pot is not affected by the first named, while only the first two movements occur in the arc lamp under consideration.

A MEMBER:—I understood Mr. Thompson to say that this motion was so uniform, that the force of gravity did not act as an acceleration. I understand that the movement is slow on account of the resistance offered by the successive rings of the solenoid. I suppose the statement was meant to be literally exact.

Mr. THOMPSON:—The principle is known, of course, that friction does not increase with the velocity, except in the case of iron against iron. It is thought that the friction varies somewhat with increase of velocity. I do not remember whether it increases or diminishes; but this, however, does not depend upon that principle. You noticed that when the holder was allowed to fall (and I was trying myself, not to perform any trick) it moved with a uniform velocity. That would not take place if I took the rod and pressed against it with some hard substance, and kept a uniform pressure on there; so the explanation must be that, just as soon as the rod begins to move, it causes the spring to spread out, and whenever a spring spreads out, it tends to spread in again, and its spreading in would prevent the carbon holder from increasing its velocity.

Mr. E. P. ROBERTS:—I understand Mr. Thompson to claim that the motion is so uniform that it does away with all necessity for a dash-pot. If that is correct, I should say that it would be most valuable in many places. I have had experience with dash-pots freezing up. One day last winter, out at Cheyenne, it took four men all day to trim 22 street lamps. In the summer you have to take them down from the poles every one to two weeks. An arc lamp has been recently patented, the coil spring in which will pull apart when it is to lift up, and when the carrier is to drop, the coils come close together and increase in diameter, and, therefore, the carbon rod drops. That motion is quite different from this.

Mr. THOMPSON:—That patent was granted to B. L. Tibbits seven months after this one was issued, and it was thought of by Mr. Wetmore and was tried, but it has the same fault about it as the ordinary ring clutch. Besides, if you try to straighten out the spring, so as to decrease the diameter of the coils—perhaps

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somebody, knowing more about mathematics, could tell how far that would have to be straightened in order to diminish the diameter a given quantity. I suppose that what you would have to do would be to measure the length of the spring and measure the diameter, stretch it, and then measure the length again, and form a simple proportion which would give the subsequent diameter of the coil. But it is apparent enough that, in order to increase the diameter one-tenth of an inch, you will have to pull this about one inch. I pull that about three inches now (illustrating), and yet the diameter looks just about as big. That is one fault about it. Another is that as it increases or decreases, of course all the diameters of those coils vary simultaneously at the same rate. They either hold the carbon rod or they let it fall.

Prof. W. A. ANTHONY:—I have been very much interested in this paper, and the device seems to me very ingenious and very useful. I rose merely to speak of what I conceived to be the theory of the action of the thing. I understand from Mr. Thompson that his idea of the action of friction is that it does not depend on the velocity except in some cases; but I have found by actual experiment that in all cases of very slow motion the friction does depend upon the velocity and that it increases with the velocity in the case of iron upon iron, and wood upon iron, and brass upon brass. After the velocity reaches a certain—not a very large—amount, a velocity of a foot a second or something like that, then the friction becomes very nearly uniform and even diminishes somewhat, but at first the friction does increase and increases considerably with the velocity. Now it seems to me that that explains very well the whole action. The pressure of the spring upon the carbon rod is a very light one, and it varies only through small amounts by a considerable motion of the magnet, as I conceive it. Now, if the pressure is diminished somewhat, the rod will go faster and so increase the friction by an increase of velocity; and if the friction is equal to the weight of the rod, then the rod will move with a uniform velocity. It is perfectly well known everywhere that when the forces acting on a moving body balance each other, the motion is uniform. Now, if an increase of velocity increases the holding force, and makes it equal to the weight of the rod, the rod will move with a uniform velocity, and that up to any velocity that would ever be allowed in the case of a moving carbon holder; so that it seems to me that that does fully explain the action.

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Mr. ROBERTS :—On the subject of not leaving the manipulation of arc lamps to unskilled labor, I may say that, of course, there are places where the labor is almost ignorant, but the arc lights where they are in general commercial use are not in unskilled hands. I have had a good many arc lamps of different styles, and I think they all need regulating of some nature or another. Any disarrangement of parts which could not be fixed by ordinary means of course would not be desirable, but I think that most men would be able after a while to adjust a spring or anything like that about an arc lamp. I think it would only be lamps that were made for special purposes where the consideration of not having to readjust a spring or a dash-pot or something or other would have to be thought of.

The CHAIRMAN :—I understand that Mr. Wetmore, the inventor of this means of adjusting the holder of this carbon, is present, and as it does not require a formal motion, unless there is an objection on the part of the members of the society, I shall call upon Mr. Wetmore. He probably has gone through all the theories and views and studies relating to this method of adjusting the holder of carbon, and I ask him to give the society his ideas and his experience on the subject.

Mr. WETMORE :—I have had some little experience in running different forms of electric lamps, arc lamps more especially, and they are continually getting out of adjustment and giving trouble. Another thing is that they are too complicated in a certain respect. A great many of those lamps have to be put into the hands of inexperienced men, men who are not well informed as regards the principles of electric lighting, and I made up my mind that it was almost a necessity to get the lamp as simple as possible, to make the parts perform as many offices as possible, and require as little adjustment as possible. Now this method of using a spiral spring for the clutch is the one I employ. This spiral spring not only has a clutch; but I may add it forms an electric contact between the incoming wire and the carbon holder. Of course the spring is always in contact with the carbon holder and the current is not interrupted, so that I make the spiral spring perform the action of a clutch, of a dash-pot, and of an electric contact with the carbon holder. It is very easy of adjustment and requires very little attention. I do not know, gentlemen, that I have any thing further to say in regard to the matter.

Mr. ROBERTS :—I would like to ask Mr. Wetmore whether in

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running his lamps he finds any burning on his rod and whether he uses any other contact besides his spiral spring?

Mr. WETMORE:—When I first started to experiment with it I found that there was a tendency to heat, but no burning; that was when I employed a very light spring; but you will see that the spring I have here is of quite large diameter, and I found that in employing that and adding the weight of the carbon to the weight of the carbon holder, it gave me a perfect electrical contact between the spring and the carbon holder, and I found no difficulty whatever in respect to burning. There were three principal points of contact in that spring with the carbon holder, and each principal point of contact is composed of several points of contact. If you will allow me I will explain that. The spring in its normal condition is perfectly straight. I pinch it in that condition and you will see it is perfectly solid (illustrating.) Now what is the condition? There are three points of contact there. That is one principal point. Here, commencing on this side, there are several—eight or ten or fifteen. There is another principal point of contact composed of several contacts, as you see. On this side again there are one or two. Now again I employ the shunt circuit to release these coils, and in what way? The main circuit may be in operation and clutch it tightly. Now if there is more current going through the shunt circuit, I employ that shunt circuit and press it on the two sides. The result is that the spring is straightened and the carbon falls down slightly. All that is necessary is to have two forked pieces right there to press it in on that spot.

Mr. FRANKLAND JANNUS:—I would like to ask Mr. Wetmore one question: Whether there is enough difference in resistance between the clutch and the carbon rod at the period of feeding to affect the light? When it lets go, when the rod moves and of course the contact is very materially lessened, does the difference in resistance then affect the light? Is there enough difference in the resistance to affect the light?

Mr. WETMORE:—That is so far as interrupting the current?

Mr. JANNUS:—Yes.

Mr. WETMORE:—No, sir; there is not. That spiral spring is always in electrical contact with the carbon holder at all times.

Mr. JANNUS:—I appreciate that point; but, when it feeds, of course it is in a position of holding together. When feeding takes place, there is just as little contact as there can possibly be. Now

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at that time, I want to know, is there a sufficient difference in contact from what there is when the carbon holder is stationary, so as to make any difference in the light?

Mr. WETMORE:—There is always frictional contact with this clutch, and that differs radically from the contact of a common clutch; that lets down suddenly, allows it to drop down quickly. With this it is constant and gradual; it is an easy sliding down.

Mr. GEORGE A. HAMILTON:—I presume the resistance is so small, compared with the resistance of the arc itself, that it makes very little difference.

Mr. H. B. SLATER:—If I understand the question of Mr. Jannus, it presupposes the case of an irregular motion when this spring feeds, or allows the carbon to feed; hence, that there is a variation in the pressure of contact, and consequently a variation of resistance. As I understand the explanation of the inventor, there is a constant and regular motion, and therefore a constant and regular pressure there. Thus there would be no variation in the resistance.

Mr. F. L. POPE:—I think that the fact that there is no perceptible burning at the point of contact, shows very conclusively that there is no resistance there. The production of resistance at the point of contact of the spring with the carbon holder, if it produced heat, would be just so much heat subtracted from the heat in the arc, and would produce a variation, but we find, as a matter of fact, as the gentlemen said, that no injurious heating is shown there. It is very evident that there can be no injurious resistance there.

Mr. THOMPSON:—The weight of the carbon holder and the carbon is considerable. In order to retain that in a permanent position, requires a force equal to the weight. That force is the pressure with which the two are in contact, and of course there is no sparking or burning.

Prof. ANTHONY:—In connection with just this point, I want to say that we have a carbon holder, a carbon rod of so much weight as there is in connection with an electric lamp, which is held so that it moves steadily with a slow motion. There must be sufficient pressure on that to carry the electric circuit without any appreciable resistance. Now, if there is here a sliding, and not an actual letting go and allowing it to drop, such a slow motion necessitates a constant uniform pressure on the rod, which is sufficient to reduce the resistance to something very little—almos nothing in comparison with the arc.

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The CHAIRMAN :—Your Chairman is not an expert in arc lighting, but a query is arising in my mind as to whether any difference is produced in the action of this spring as the carbon itself becomes consumed, and therefore makes less weight to the carbon holder.

Mr. THOMPSON :—All I would say would be that that amount of weight taken off would not amount to much, as 75 per cent. of the weight is due to the carbon-holding rod, which is a long tube of metal.

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Read before the American Institute of Electrical Engineers, May 20, 1885.

DESCRIPTION OF A LARGE SECONDARY BATTERY PLANT FOR GENERAL COMMERCIAL DISTRIBUTION.

BY E. P. ROBERTS, M. E.
(General Manager of the Brush-Swan Electric Light Co., of Cheyenne, Wy.)

1st. Description of the storage plant.—2d. Direction for erecting and maintaining storage batteries.—3d. Remarks respecting storage batteries and their field of usefulness.

A description of our entire plant, both arc and incandescent, was published in the *Electrical World* of February 28th, 1885, and from that article will be quoted a description of our battery plant.

The Brush-Swan Electric Light Co., of Cheyenne, was formed in the fall of 1882, and was the first Brush-Swan company formed to use the Swan lamp in conjunction with the Brush storage battery and arc system. Storage batteries were put in operation early in 1883, and at the present time 99 batteries and 1,500 lamps are in operation, distributed over an area about one mile square, the charging station for the batteries being about one-quarter of a mile outside the north-west corner of the square and over 300 of the lamps being in the south-east corner.

BATTERY PLANT.

"On each block—sometimes on every two blocks—is located a small portable house, in which are placed all the batteries furnishing light for said block. A partition divides it into two parts, one for the batteries and the other for the meters and switchboard. A plug switch is used in order that any combination may be readily effected. Cable connections permit coupling batteries together as desired. An extra battery is kept in each house for use in case extra light is required.

"The batteries are placed on string pieces 2 inches by 4 inches by 10 feet; each cell rests on four porcelain insulators, and the string pieces rest on Western Union insulators, with pins set in cross-pieces. Three sizes of batteries are used, 1, 2 and 3, with capacities of 20, 40 and 80 lamp hours respectively.

"Three charging circuits are used, two to private residences,

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where Nos. 1 and 2 batteries are used, requiring from 7 A. M. to 1 P. M. to charge them with a 10 ampère current, and one circuit to the business part of the city, where batteries are used. As these batteries are much larger, a longer time is required to charge them, and, therefore, they are charged from 7 A. M. until 3 P. M. by a 65-light dynamo. They are then connected by switch, as desired, for the night, in some cases three batteries being connected for quantity.

"At dark the charging circuit is looped in with the all night outside arc circuit, and the charge thrown on about 20 meters, and by the connections for quantity controls about 50 batteries; thus they are left until daylight, when the arc circuit shuts down. By this means the batteries obtain considerable charge; they are then disconnected and charged separately during the day."

Directions for Erecting and Maintaining Storage Batteries.

A. CAREFUL INSULATION.

1st. Battery as a whole well insulated from the earth.

2d. Each cell insulated from all others, excepting, of course, through the proper channel for the passage of current.

3d. The positive and negative in each cell to be insulated from each other except through the liquid. No connection by moisture on the upper edge of the containing box.

B. REGULAR CHARGE AND DISCHARGE.

1st. Fill the battery every day.

2d. Discharge the battery every day.

3d. Never over-charge.

4th. Do not exhaust completely.

C. DO NOT EXPECT BATTERIES TO TAKE CARE OF THEMSELVES.

1st. Test electromotive force of each once a week with a voltmeter.

2d. Test each cell with an acidometer once a month.

3d. Each day see that each cell in each battery fills in the same time.

4th. Keep plates covered with liquid.

5th. Examine all connections frequently.

D. Keep extra cells complete and charged, with which to replace defective ones. Do not put uncharged plate or cell in battery in regular use.

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E. Do not "box in" batteries. Give free circulation of air.

F. Keep all connections, switches, etc., as far as possible away from batteries.

G. Study the cause producing a new effect, and attend to details.

REMARKS.

After considerable experience with storage batteries, my conclusion is that they have been both praised and belittled too much. That the service can be good is certain; but that, for a closely settled district, they are preferable to dynamos is not, according to my experience, correct.

Experience teaches the manufacturers many points in design and formation which greatly increase the reliability of secondary batteries. Experience in handling them teaches men many little matters which greatly assist in keeping the batteries in good condition.

My plan for our new station about to be erected will show, more forcibly than a lengthy disquisition, my ideas respecting secondary batteries in connection with stations for the distribution of electrical energy.

A building is to be erected near the business portion of the city, from which our arc lights will be supplied, and in which also will be placed dynamos for running the incandescent lights in the business district. Batteries will be used in portions distant from the station. These will be charged from 3 A. M. until 7 A. M. with a 15-ampère current. At the station will be several large batteries, which will be used for day lighting or in case of a breakdown.

DISCUSSION.

The CHAIRMAN:—The subject is now before you, gentlemen. Mr. Roberts is especially prepared to answer questions in regard to the practical operation of such a plant.

Prof. W. A. ANTHONY:—I would like to ask Mr. Roberts what his experience has been in regard to the durability of the lead plates.

Mr. ROBERTS:—We have been running since the early part of 1883, so that we have had a fair experience; but what the plates will do at the present time it is hard to say, because they have improved so much. At first there were six cells in one long box, the wood of which was all continuous. The plates did not have room to expand and they were not as good, nor did we know how

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to attend them as well. But we have had better plates running for over a year in those batteries, which do not show any sign of disintegration. Our experience in learning what to expect, and what not to expect has been of great value, as we are enabled to attend to every little matter before it becomes too serious. It is hard to say what the most recent batteries will do. I could say as to one year well enough, but I would not like to say as to three or five.

Mr. HALL:—The batteries you speak of are constructed essentially upon the principle of the Planté cell, are they not?

Mr. ROBERTS:—In this Brush battery, you know, the cell—the positive—it is a gridiron in shape, corrugated ribs between two negatives, and the distance at first used to be very small; I think it was three-eighths of an inch. The idea of course at first was to get the resistance as small as possible, but I don't think that practice made much difference there. At first there was great trouble from short circuiting; a rib would sometimes at first gradually become oxidized around under the rib, and the top part would fall over and hit against the negative.

Mr. HALL:—That occurs especially at the bottom of the cell.

Mr. ROBERTS:—If the sediment collected; sometimes it would occur right at the top of the cell. But in the present form of battery they have room to expand.

Mr. HALL:—Have you ever had any opportunity to observe how the electromotive force of the cell fell off if it were not used immediately after charging.

Mr. ROBERTS:—My paper, of course, is not one of scientific figures. Nevertheless my directions for using storage batteries show that it is advisable to have them charged and discharged every day. Of course it does fall off, and for that reason I say, discharge every day. Another thing is, when they lie idle, the resistance is very much increased, and if your manipulator, as they call it in their catalogue, or if the mechanism for throwing the current on, has to overcome that immense resistance at first, you have to look out for it, because it should be made with more points of break and contact than it has.

Mr. HALL:—A cell of that sort deteriorates from lying idle after being charged. I wished to know what that rate of decrease was if you had observed it.

Prof. ANTHONY:—In charging are the indications of the manipulator followed or some other plan?

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Mr. ROBERTS:—As a general thing we charge according to the manipulator which is the time of charging the battery, and which bears a very close relation to the time of discharge, when they are properly arranged. We had great trouble at first in doing that, until we introduced this storage battery-house system. Each man has his battery in that place. He is independent so far as he is concerned. The man keeps constant watch, and tells by observation, without the strain of thinking—at least he notices—if a battery takes much longer to charge than is usual. Then he tests that battery, running over each coil with a wire, and if everything seems all right, it is supposed that they use that light. If he finds anything wrong, then he makes a note of it in a paper that hangs up in the battery-house. If there is any unusual change—if a man's bill had been running six or seven dollars a month and we find it is twenty or thirty dollars—we pay attention to it; but that does not often occur. And so I think we can safely say, that the time of charging is the record by which we charge our customers, and it is satisfactory, too.

Mr. F. L. POPE:—It seems to me that we can see very plainly from Mr. Roberts's paper that a large share of his success is due to his system of placing the plant in charge of trustworthy and intelligent employees. This is a matter that is getting to be altogether too much overlooked of late years. It is coming to be quite a common practice with electrical companies to draw up a code of strict rules and regulations, mainly theoretical, and then find somebody who will work for four dollars a week to carry them out; and, in case of failure, pretty nearly everybody but themselves is blamed. And that has been quite largely the case with storage batteries, I fancy. They have been set up and placed in charge of anybody and everybody, and expected to take care of themselves; and I suppose it would be difficult to find anything that requires more intelligence and careful attention at the right time than they do. If anything goes wrong with a battery, and there is anybody who understands it to attend to it, it is rectified in a moment. If it is allowed to go on, it results in considerable damage.

Mr. ROBERTS:—I might say, in respect to the men, that, at first, we had hard work in getting them. It is a new country, and we have to train the men. We managed to get a few who were trained in other lines, somewhat. One of our best men had been an electro-plater and a manufacturer of electrical instru-

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ments, and our foreman of battery work has been a telegraph lineman. What we intend to do is to pay good wages, and if a man does not come to time, turn him out. We are pretty strict about that, and the consequence is we get fairly good service. But the men who attend to the batteries, who do the most work about them, are not what you would call skilled laborers. One of them had been a farmer's boy, and never had anything to do with machinery. But from constant attention to it, they get to know pretty well what to do. The foreman has been at it ever since he commenced working. He generally inspects and the others report to him. If the man who is in the battery-house, and has that circuit in charge, "blows" on the battery, to use our Western term, he gets pretty well "wound up" about it. They feel a pride in their work. I have every man, as far as possible, responsible for the work under him. Many of them take considerable pride in it, and are badly hurt if things do not go right.

Mr. R. W. POPE:—As I understand Mr. Roberts he does not pretend to compete with the commercial price of gas. It is evident that he is proceeding on a more business-like principle than a great many in the business.

Mr. ROBERTS:—The gas company started after we did. The two principal men in the electric light company and in the gas company, have been opposed in politics and stocks and everything else out there, and whenever one starts a thing, the other starts something else in the same line. Our first batteries were very defective. We did not know how to handle them. An entertainment would be given by a customer, and suddenly the lights would go out. The gas people saw their opportunity and the company was started. I favored sticking to our price until we found how the gas company came out, because it is a good deal harder to raise your price after you have once dropped it than to stick to your price. We stuck to our price and got orders right along so we staid there. The other day a gentleman who is building a new house came to us and asked what we could furnish light for. We said $3.50. He said "I can get gas for $2.75 but I would rather have the electric light. I told what I could get gas for to see if I could induce you lower your price. But I would sooner have the electric light at $3.50." There was a very large house built the other day with handsomely frescoed ceilings. Gas was put in, and now the owner wants the electric light because the ceilings are getting darkened.

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Mr. F. L. POPE:—I think that is a cardinal mistake that has been made from the beginning in the electric light business; to endeavor to compete with gas in the matter of price, when every well-informed electrician has been perfectly well aware from the beginning, that in the present state of knowledge, it was not possible to do it, and for that reason the attempts which have been made to furnish house-to-house lighting from central stations have not been commercially successful, as far as my knowledge extends. Now it seems Mr. Roberts has adopted a very intelligent plan in his operations. Where he can use direct lighting he is doing it. Where direct lighting cannot be commercially used he is using something else. He is adapting his methods to the place where they are to be employed, and he is endeavoring to charge a price which will give him a fair profit on what it costs him to do it, irrespective of whether the gas costs less or more. I think that any one who has had any experience in the use of the incandescent light would not have the slightest objection to paying fifty per cent more for the electric light for their house than they would for the gas light. I speak as I feel about it. I should be willing to pay fifty per cent more rather than not have it. It is in a certain sense a luxury. It is only a small part of your expenses, and you do not count them any more than you figure up your glasses of soda-water per week. Therefore I think the electric light people have proceeded very largely on a mistaken plan in that respect. Perhaps it originally came about from a feeling that people would not invest in electric light enterprises, unless they were made to believe that the light could be furnished at a greater profit than gas, at a less cost. Perhaps it was necessary to state things in that way, in order to make people put their money into it. But I think men who have done so have found out differently since that time.

Mr. ROBERTS:—I intended to mention when I was speaking before, that Mr. Potter promises to send out some glass cells. We are not using them yet, but their use will prevent the short-circuiting of cells by one touching the other, and it will largely prevent the creeping on the edge, which is also bad, and we will also be able to see down, particularly if we put an incandescent light behind the reflector, and observe the condition of the plate.

Prof. ANTHONY:—I heard something about a company that made glass cells, about a year ago, and I was anxious to know if they had been tried and what their success was.

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Mr. ROBERTS:—I only know from hearsay, and that is what Mr. Potter told me in Cheyenne. I do not remember where he said they were used, but he said they were working well.

A MEMBER:—We use glass cells for secondary batteries. We used wooden boxes, but we found that, after a month or so, they began to leak and then made some stronger boxes. The last two were made of glass, and now all the cells are made of glass. They put india-rubber between the plate and the glass; that is as we use it in Europe.

Mr. ROBERTS:—Those strips must be in the liquid. The liquid must go to the glass. Therefore those strips could hardly be insulators. They could only be used to keep the cells in position.

THE MEMBER:—The strips are on the outside, and inside there are only pieces.

Mr. THOMPSON:—How are those joints made in the cells? You say they leaked a little at first, and then they did not leak. I made a lot of cells by flattening the lead, cutting in certain directions so that, when folded up, it makes a complete box, and then taking a Bunsen burner, and getting a little sharp flame; and by teaching the mechanic a little, and by his practising, he could run that along slowly, and could make lead pots. About two years ago I saw some of the Brush cells. They were simply soldered. I tested one and it was leaking. They would last for a long time, because the acid attacking the solder would take a long time to eat through the solder, the solder being placed on the outside, and the acid attacking only a very small area of the solder at once. I was wondering how they were made at present.

Mr. ROBERTS:—The way they are made of course I do not know, because we get them from the Brush Company. The first did leak, but they did not leak so much on the solder joint as they pitted through. They claimed that the lead was not pure and it was not heavy; a little indentation would almost go through. I presume they make a burnt connection. There is no solder used. It is all lead and fused together. I do not know their exact method of manufacture.

Mr. SHELBOURNE:—This whole question of the cost of electric lighting, compared with gas, depends upon so many conditions and considerations, that it would be hardly fair to make an estimate off-hand on the cost of one or the other. It has been stated generally in the newspapers that the Edison Company claim, in regard to incandescent lighting, that they can furnish light cheaper

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than gas. I do not know whether that is directly claimed by the most responsible persons in the Edison Company or not. My friend here, Mr. Pope, seems to take it for granted that it ought not to be considered that lighting by electricity is as cheap as gas. Now this whole question depends upon just the relative conditions of giving an equivalent for the money. It is a *quid pro quo*. Do you get your money's worth? What are the conditions that enter into the question of the value of the electric light? Well, it has been stated and considered that one of those conditions is the comfort that you derive from the electric light, the mellowness and steadiness of the light, the freedom from carbonic-acid gas, and those other considerations. Another very important thing depends upon the photometric quality of the light—the amount of light that is given. Take the arc light in this city. The Common Council have requested the board that has charge of the lighting of the city to put the electric light in certain streets. Recently the city official having charge of the gas and the lamps reported that, taking the streets where the electric arc light was used for lighting, they cost so much. The gas lamps that were replaced by those arcs cost so much. The result was that the cost of the electric arc lamps was about three times as much as the cost of the gas lamps displaced. It was stated, however, in the report that no question was made as to the amount of the light. Now that is very important. The question is as to the amount of light, and as to the comfort that you derive from the light. That furnishes the *quid pro quo*—getting your money's worth. Of course, when you come to incandescent lighting, people who have had gas in their rooms, when they supplant that system with the system of incandescent lights, they would not be satisfied with the same amount of light that they had been deriving from gas. They want something that is better; they want something that is new, and that furnishes them with something different from what they had before. They get at least fifty per cent more of light with the incandescent light, and then they go to work to compare the cost of their previous gas bills, and they consider—well, really this light cost fifty per cent more than our gas. They have not measured the light. There are so many different ways of measuring the quantity of light and such variations in regard to the accuracy of instruments in measuring lights, and so many considerations in regard to measurement that they never put the question to the practical test—that is, how much light do we get for so

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much money? Until these matters are reduced to careful calculations and measurements based on experiments, it will be impossible to say what the value of the light is or how much money it costs.

Mr. ROBERTS:—Our electric light company is a small corporation, I mean the number of men in it; there are only four. Two are residents of Cheyenne and the other two are there only during the cattle season. They distributed the stock very largely, and they have got a number of men interested more or less, in one way or another. The question came up before the Common Council last Fall, as to whether we should have the electric light or gas for the streets. The gas people fought pretty hard and we did our best, but were only two against a large number. But when it came to a general discussion on the street and the members of the Common Council found what their constituents were going to say, we had a majority in the board and they voted unanimously for the electric light. The gas company bid a hundred and thirty-five lights of customary candle power, as they called it, which gave rise to a few remarks on my part, because customary is rather an odd term to bid, and we bid 22 lights and secured the contract for three years.

Mr. HAMILTON:—In this particular plant about what percentage of the charge is returned. I should be very glad if Mr. Roberts could give us any information in regard to this.

Mr. ROBERTS:—I have said that my paper is not one of figures and therefore I do not feel quite ready to answer questions respecting matters of that kind. The Brush Company reported seventy-five per cent as the efficiency, and I do not see any reason to doubt it. It depends very largely upon the conditions.

THE CHAIRMAN:—There has been a good deal said about the comparative cost of incandescent lighting with that of gas. Now it has not been stated, but I do not think there is any question about it, that gas at the present time is far more costly than kerosene, and yet it displaced it. Now it seems to be thought by some, that electric lighting ought to cost more than gas, and it is stated by some that even on those terms it ought to hold its own. I think Prof. Card can give us some information on that. The point is this, that up to the present time, the discussion has elicited the fact, that in the plant operated by Mr. Roberts, they obtained higher prices for incandescent electric lights, than are charged for the same amount of illumination by the gas company in his town based upon the question of quality. The chair merely suggests.

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that we would like to hear from Prof. Card, what his ideas are of what the relative prices should be between electricity and gas, in this part of the country.

PROF. CARD:—I did not expect to say anything when I came in here, but this question of electric lighting, or as I call it thunder and lightning business, selling the lightning and throwing in the thunder for nothing, is a good deal a question of education. You take kerosene. It doesn't cost a great deal—fifteen cents a gallon. You take your gas at $1.50—it doesn't cost a great deal. But if you can get a better light from the gas, you don't count so much the difference in cost. As this gentleman says, if you can get a better light from the electric light, you do not consider the cost of the thing. As to the relative cost of running a plant, why it depends largely as this gentleman said on the conditions—what the size of the plant is, how many hours you run it; because for a fifty light plant, it will take about the same organization as for one of five hundred. If you run it but an hour, you have to have your men look after it as though you ran it ten hours a day. The longer you run an incandescent lamp, the cheaper it is relatively. It seems to me the reason of that is apparent. To go back to the start, it is a matter of education. When you bring out a new art, people don't know much about it. They learn by observation. They study the thing up and figure it up. You show it to them and show them it is a good thing and just what they want. They don't look at the element of cost at first or at any time. If it is an improvement, if there is more comfort to it, if it is healthier, if a man wants to fix up his house nicely, and to decorate it with fine tints and colors, that the sulphur from the gas would tarnish, while he could put in the incandescent light and save those tints and colors, that is an argument in favor of it. From my observations here in town, since this incandescent lighting business has been running, there is nothing like the opposition to it, on account of the cost that there was, because it can be made to come pretty close to any decent sort of gas. The incandescent light can come very closely to it, so near that there is nothing like the talk as to matter of cost that there was, because it is so much better than the other.

Mr. SLATER:—There is one point that I think has not been touched upon; that is the matter of health. I think in that respect especially the incandescent light far surpasses the gas light or the light of the kerosene lamp. When a gas light or a

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kerosene lamp has been burning in a room and one comes in from the open air he can detect its presence at once. I cannot remain in a room where a gas light is burning without inconvenience. There are a great many who are the same, and who suffer from that cause in various ways. With the use of the incandescent lamp we have nothing of the kind. The air is not vitiated at all. The light is steady as compared with the gas light. In fact it is perfectly steady you might say. A great many, like myself, cannot read by the gas light. I cannot use the gas light at all. I have to use a kerosene light for the purpose of reading, and the incandescent light surpasses the kerosene light in that respect. The health is affected by the effect on the eyes. The health is affected by the vitiation of the atmosphere of the room; and taking all together, the comforts derived from the use of the incandescent light, as compared with the gas light, are considerable, and we should not, I think, consider the difference in price. Of course it is a matter of education. You and I can buy butter for forty cents a pound. Our neighbor can buy butter for twenty-five cents a pound. It is all butter; but I could not eat the twenty-five cent butter. I should suffer very much in my digestive apparatus, if not otherwise. Fuel, which we generally call coal, is all coal; but one kind of coal perhaps cannot be used in the house, which we purchase for, say four dollars a ton. We pay five dollars. It is only coal; it is all coal, and to the ordinary mind it is one and the same thing; but we get a better result and a more economical result from the higher priced coal. We certainly get a better result and a more economical result from the use of the incandescent light as compared with gas, although we pay a high price for it. The doctor's bills will certainly be less than with the gas light, and there will be a higher degree of comfort. As has been well said, it is all a matter of education; people should be brought to see the difference in the effect upon the health, and the difference in the volume of light. It has seemed to me that if some instrument could be invented which could be supplied to the people cheaply, to measure the volume of their light, or be placed in the hands of such parties as are selling light, to be used when advocating the sale of their light, whether by gas or electricity, then the people could see the difference. As it is now, it is hard to get some people to detect the difference even between a gas light and a kerosene light; I mean the ordinary kerosene burner. It is

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very difficult also for them to see the difference between the incandescent light and the gas light. I have met people who could not see the flickering of the gas light when I could not see to read for that reason. But such people cannot be convinced unless some instrument can be produced by which the volume of light can be measured and it can be shown there is a difference between the two lights, just as there is a difference between a pint and a quart measure.

Mr. ROBERTS:—Taking up the gentleman's last remark, first, I would say that I made an exhibition in the Windsor House at Denver, some years ago, some gentlemen having requested me to show if there was any difference between the lights. They turned off the electric light first and tried to read by the gas light, moving away from it gradually, and then they tried the same thing with the electric light and they found they could move much farther from the electric light than from the gas light and read. In a printing office I know of a case where the proprietor wanted to dispense with the electric light, and the men said, "If you are not willing to pay for it, we will pay for it; we do not wish to do without it." In the jewelry store at our place the man who repairs watches has to have a light close to his eyes and he always used a student's lamp before—well, a student lamp is as good as a gas light, I think—and he could not work late at night on account of the trouble from heat, etc., and he prefers the electric light. If a man is a small consumer of light and he uses kerosene, and his bill for kerosene comes in with his groceries and the servant girl cleans his lamps, it does not amount to anything; but I have put an electric light in a hotel for what they paid a man to attend to the lamps. They paid a man two dollars a day to attend to the lamps. We have lighted two hotels there and I certainly think in one of them it cannot cost much more, if any, than they used to pay for attendance. In one of them they were refitting, putting in new carpets, and we kept them waiting four or five days to open that part of the hotel. They would not start that part of the hotel with kerosene oil, because, they said, the men might spoil enough carpet with the oil to pay for the difference. The advantages of an incandescent light are too well known to go over; but the advantages are recognized very largely by people who use it right along, and with it they can economise in so many ways that they cannot economise with gas. Two nights ago I arrived at my old

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home near here. I wanted to light the gas in my room during the night, and in trying to find a match I tumbled over chairs and other things. Now, at home I have no trouble of that kind.

Prof. CARD:—I have here a clipping that I took from a newspaper. I do not vouch for the truth of it; but if there is any truth in it, it emphasizes the remarks made by a gentleman a moment ago as to the hygienic effects of artificial light. It is an extract from a lecture by Mr. R. E. V. Crompton, at the Health Exhibition in London. "Turning now to the comparative heating and air vitiating properties of artificial lights which we shall find it convenient to take together, I have here a table prepared showing the oxygen consumed, the carbonic acid produced, and the air vitiated by the combustion of certain bodies burning so as to give the light of twelve standard sperm candles, each candle burning at the rate of one hundred and twenty degrees per hour:

	Cubic feet of Oxygen Consumed.	Cubic feet of Air Consumed.	Cubic feet of Carbonic Acid Produced.	Cubic feet of Air Vitiated.	Heat Produced in lbs. Water, Raised 10° F
Gas.....	5.45	17.25	3.21	348.25	278.6
Elec. Light	None.	None.	None.	None.	13.8

Mr. ROBERTS:—There was one remark made a little while ago, to the effect that the expense of running depended somewhat upon the labor and the number of lights. We have to furnish lights during the daytime to cellars, dark offices, etc. Now we are going to have large batteries, as I mentioned in the paper. We have large batteries there in our stations. Those will be charged during the night time and they will be switched on to the main line during the daytime. Therefore we will not have an extra relay of engineers and firemen, and in case of a breakdown we will switch those on at once. It is done by the movement of a handle, of course. If the breakdown is in the power, we order an extra engine, and before the engine reaches us we have its capacity nearly filled up, and are obliged to get another one. We supposed we had a hundred per cent. more power than we needed a year ago and now we haven't enough.

Mr. F. L. POPE:—I would like to ask Mr. Roberts if he knows of any other similar storage plant and incandescent outfit running anywhere in the country.

Mr. ROBERTS:—No, sir; we have the only one, so far as I know. We started first and have been pretty much alone. We

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have had a good many letters of inquiry to know how we were getting along, etc. We had some pretty hard times, but we had enough pluck to stick to it. I have heard from Mr. Martin that there were some gentlemen in town who said it was very pretty out at Cheyenne, but that is out of the world. But, for all that, it is connected pretty closely with the rest of the world and a great many men know pretty well what is going on out of Cheyenne. I went to quite a stylish store in New York recently and they had an old-fashioned Brush lamp burning. They would not have such a thing as that out at Cheyenne. They insist on having nice brass lamps.

Mr. F. L. POPE:—The impression had prevailed that the system had been an entire failure, and it certainly was quite a surprise to me and to a great many others, I have no doubt, to hear of what Mr. Roberts had been doing and of the great measure of success that attended him. It is evident that he has got through the worst part of it and will have plainer sailing from this on.

The CHAIRMAN:—About a year and a half ago an incandescent plant was put into the Smithsonian Institution at Washington, by Mr. Shea, and so long as it was operated at all it was quite successful, although it was not operated long enough to furnish any comparative data. Then there is another incandescent plant in Washington at the printing office of the *Republican* and *Post* newspapers. That has been in operation for more than a year and a half. In fact I think it is more than two years now. That is operated direct from the dynamo. I have never, however, had any of their figures and cannot give the expense.

Mr. ROBERTS:—The plan of using in the station, is what I believe to be the best use of the storage battery. I believe we will make a good thing out of it. We don't look upon the storage battery as a failure; but we do not believe in it where we can get a number of customers close together and where we can get a station near it.

Mr. MARTIN:—I am responsible, according to Mr. Roberts, for putting up a job on him apparently. But I was so much interested in the statement he made to me that I suggested he could not bring a more timely subject before the Institute than the subject of storage batteries. There is one point I want to inquire about, "Batteries will be used in places distant from the station." From that I gather that the lights are used in private houses.

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Mr. ROBERTS:—Yes; very largely. We have two private residence circuits. We have lights in every conceivable place there almost. We have them in houses of all kinds of repute. We have them in gambling houses, churches, private residences, business places and every possible place you can imagine. We have them in the telegraph office and in the despatcher's office of the Union Pacific Railroad, and for all those places we are obliged to have special arrangements.

Mr. MARTIN:—In that case are you prepared to give your support to this statement which I find in the *London Electrical Review* of May 9th, which I received yesterday:

"Two years ago, or even less, we should have been very guarded in anything we had to say in eulogism of secondary batteries, but such very decided improvements have been made in these apparatus that for such purposes as that to which we have referred before they may, under periodical and intelligent inspection, even now be safely recommended, and it is not too much to assume that as they are better understood so will further improvements follow."

If you after your experience can endorse that I think it would be saying a good deal for the secondary battery. I should also like to know if you can say anything regarding the use of secondary batteries on the railroads of the country.

Mr. ROBERTS:—As to railroads I can say nothing more than what Mr. Potter told me the other day. I think he referred to the Pennsylvania Railroad. The results thus far obtained were very promising. With respect to the extract from the paper which Mr. Martin has read, I do not see any exception to be taken to it, provided consumers are willing to pay for what they get.

In such cases where they have water-power it would probably be cheaper to have a dynamo and a storage battery than gas. In other places it might be cheaper for them to put in gas. The main fact that they would under periodical inspection give a good light and be fairly economical I think would be correct.

Prof. ANTHONY:—I have never been able to find out yet what a storage battery costs—the first cost of one—and if that can be told, I should like very much to know. Of course, if it is a secret, I do not want to press the question.

Mr. ROBERTS:—All the information I have on that point is from the private circular of the Brush Company. It is a private circular, and I am compelled to refer you to the Brush Company.

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Mr. F. L. POPE:—From all that has been said it seems quite clear that the field that has been occupied by the storage battery is in the way of supplanting the direct system of incandescent lighting. This direct system is only practicable now for very short distances from the central station. When you go very far away, the interest on the cost and maintenance of your conductors mounts up so rapidly, that the cost becomes prohibitory. Now the storage system is evidently going to permit the economical extension of incandescent lighting systems to a much greater distance from the central station.

Mr. ROBERTS:—I think by next fall we will be lighting a group of residences—new residences about two miles from our station; but it will depend somewhat on how we come out with another group in the same direction. If the Government takes hold, the officers will probably light their residences also. Mr. Martin hands me a paper here saying that the Boston *Herald* has an isolated plant of about three hundred lights and it costs less than gas.

Mr. MARTIN:—In their case would it be to their advantage to light from a central station or storage?

Mr. ROBERTS:—It would be advisable for them to stick to what they have most decidedly.

Col. HAZARD:—I should like to ask, sir, whether the question of generating by wind power only, has been the subject of any experiments—that is charging the dynamos by the wind only.

Mr. ROBERTS:—Respecting wind only, one or two gentlemen in Cheyenne who have ranches far from town have spoken to me about it, and I have been too busy to go out and give them any figures But when you have your machinery and engines, and are obliged to have skilled labor, I think that the steam engine is the best. Very large windmills would be necessary. Say you put in fifty horse power. I believe that a twenty foot mill doesn't give more than one and a half horse power, and you would require a good many to give fifty horse power. Then our air is rare, though we have a high velocity at some seasons of the year. If you had windmills alone, you would have to have an extra storage plant to last you at least two days.

Prof. ANTHONY:—There may be cases where wind power would be valuable for such purposes for an isolated plant, but it seems to me that in most places there would be days or even a week together, where the mill would not run with sufficient velocity to

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generate current enough to charge the battery. Unless you had the wind to do that, you would be without a charge for days together. It seems to me it would be an exceedingly unreliable power. My own feeling in regard to it is, that steam power is the power for electric lighting; that even water power is not a power that is to be considered in comparison with steam; except under very favorable conditions. There are of course cases where the conditions are so favorable, where you can use it and rely upon it continuously from one year's end to another; but in a great many cases the water power fails at just the time you want the light. At Ithaca, where we are doing something in the way of electric lighting, and have water falls enough—if the fall were all that was necessary—to generate any amount of power. We have between our University and the lake about four hundred feet of waterfall; but the trouble is that in some seasons of the year there is not much water. If we could be sure of water, I think we might use water power with perfect success; but occasionally the water fails and then again there is more or less trouble from the running of debris in the stream that clogs up the wheels, and my feeling has been that if we want a continuous and reliable electric light, something that will not fail us on occasions; if we want a light that people can always have at command when they want it, like gas light, there is nothing like the steam engine.

Mr. THOMPSON:—We had a windmill which we connected up over night with a steam engine accidentally. In the morning we found the steam engine running without any steam.

Mr. R. W. POPE:—In regard to water power, I was at one time with an establishment where we needed a continual supply of paper for ticker instruments. Our paper came from a Holyoke mill. At one time they didn't have water enough and again there was a freshet, which interfered with the manufacture. So I got discouraged and hunted up a paper mill in New Jersey that ran by steam and we had no further trouble in that respect.

Prof. ANTHONY:—I have been very much interested in this discussion and in the original paper, and I have been watching this storage battery question ever since the storage battery was introduced. It seems to me that the storage battery is as necessary for the solution of the problem of electric lighting as the gas holder is for gas lighting. I think that the thing we want is coming sometime. But there are a great many questions involved and one of these is the original cost of the battery; that is what

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prompted the question I asked. I have heard the statement made that a storage battery that will do the same work costs three or four times as much as a dynamo, and a great many people have said who profess to know something about it, that the first cost of the battery, the interest on the cost and the depreciation were so great as to almost prohibit the use of it; and I am very glad to know that Mr. Roberts has found the thing such a success that the plant is being increased. That is evidence to me that they have found it valuable at any rate, and I do not see how it is possible for us to extend over any large area this system of electric lighting except by some such means. Certainly we can light small areas directly from the machines, but when you come to go any distance you must have the storage capacity, and until you have a battery you can use, you have not reached the solution of the problem of electric lighting.

Mr. CAREY:—Mr. Roberts has kindly given us a great deal of information upon the importance of charging and discharging the batteries. I would like to ask him to give us a few words explanatory of the disadvantage of failing to do that, and whether or not it would be at all practicable to carry this charge in the battery for a length of time; provided our power was furnished for nothing as by the windmill.

Mr. ROBERTS:—Of course if you overcharge you must disintegrate, and you also oxidize your plate. Respecting leaving it uncharged, it does not deteriorate rapidly to leave it uncharged. It is a great deal better to take the plates out and pile them up. If they stay in the liquid and are neither charged nor discharged; there is an action going on continually which gradually disintegrates them. To do it every day is the point we aim at and which we succeed pretty well in following.

Mr. CAREY:—What age have you given to any of these batteries without using them?

Mr. ROBERTS:—Well, I do not know. We have not had any time, or an experimental laboratory to do anything, to see how bad it was.

Mr. SLATER:—With regard to leaving the storage battery uncharged I have had a little experience. I have a series of six at Elizabeth. They are made of lead, two pounds per square foot. They have been left uncharged since the first of January, and within the last ten days I have had to pick the rims of the plates out of the bottom of the cells, all disintegrated and destroyed.

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Mr. ROBERTS:—The first exhibition we made we ran for over two hours with four lights, with two No. 2 batteries, using the charge that had been in them before they were shipped to us. If they are shipped dry and kept dry it is all right; but if you put them in the liquid and let them discharge, the resistance is very high.

THE CHAIRMAN:—I think we owe a great deal to Mr. Roberts. He has come a long way to read his paper to us. I do not think there is a member present who has not been intensely interested in what has been said; and I think that the information Mr. Roberts has been able to afford us is really exceedingly valuable, because of the very small amount of attention that this subject has received, and I think that we ought to express our thanks to him at least, verbally.

Mr. ROBERTS:—After the Chairman's very kind remark, I would say that I was only sorry that I could not elaborate the subject a little more. When Mr. Martin first asked me to write a paper I did not expect to come East and read it. I was rather afraid that when I gave this short paper, it might be considered that I did not feel the honor that I ought to feel in reading a paper before the Society. Instead of that I am very highly gratified by the reception it has received.

Mr. MARTIN:—I move that Mr. Roberts be asked to present at our next meeting, a paper stating the progress he has made with his secondary battery plant in the interval.

The motion was carried.

Mr. F. L. POPE:—I suggest, Mr. Chairman, in connection with the paper we have assigned to Mr. Roberts, that I am sure all the members would be very glad to have any information which he may find convenient or possible or proper to give us, in relation to the actual cost of working the plant. That is a matter of a good deal of importance, and with the experience he has had, he may possibly throw more light upon it than we could get from any other source.

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A paper read before the American Institute of Electrical Engineers, May 20, 1885.

DELANY'S SYSTEM OF FAC-SIMILE TELEGRAPHY.

BY PROF. EDWIN J. HOUSTON.

Fac-simile telegraphy embraces the methods by which chirography, outline sketches, maps, hieroglyphics, etc., produced at one end of a telegraphic line, are automatically reproduced at the other end. Such a system embraces a transmitting instrument at one end of a line and a receiving instrument at the other end. These instruments, though varied in form, consist for the greater part of similar surfaces maintained in approximately synchronous motion. The message is written or drawn on one of these surfaces, and is automatically reproduced on the surface at the other end of the line.

Numerous and various devices have been invented for the transmission and reproduction of fac-simile despatches. The principal of these may, however, be arranged under two heads. In one of these classes a pen or stylus, moved by the hand through a magnetic field, sends thereby a series of electrical impulses over the line that produces corresponding movements in a similar pen at the other end of the line. In such apparatus the handwriting or outlines are reproduced directly on the paper or other material that is placed on the surface of the receiving instrument.

In the other class, which embraces the greatest number of apparatus, the transmitting and receiving devices are of the same construction and consist of similar metallic surfaces, such for example as that of two cylinders maintained in approximately synchronous motion, and each provided with a pen or stylus that is caused to move over the surface. The pen or stylus is connected to the line so that the current passes from the transmitting instrument over the line and into the receiving instrument. The message to be sent is written on the surface of the transmitting cylinder in any non-electrical conducting ink, and the surface of the receiving instrument is covered with ordinary Bain paper. When now the instruments are simultaneously set into motion, as long as the stylus or pen is in contact with the metallic surface of the transmitting instrument, it causes a continuous blue line to be traced on the Bain paper at the receiving end. When, however, the stylus or

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pen is moved over the surface of the non-conducting ink, the circuit is interrupted and the corresponding points on the surface of the receiving cylinder are left unchanged. The design traced on the transmitting instrument is thus reproduced on the receiving instrument in white on a blue ground.

Bain was the pioneer in fac-simile transmission. His devices, which were produced as early as 1843, belong to the second class of apparatus. To the same class belong the inventions of Bakewell in 1850, of Hunter in 1852, of Caselli in 1858, and of Bonelli. The devices of Lenoirs, of Sawyer, of Edison, of others may also be included in the same class.

The apparatus of Jones, produced 1855, and of Myers, belonged to the first class.

Thurrell, Müller and Chidly, in 1856, produced, jointly, an apparatus for fac-simile transmission, in which a magnetized point or roller was moved to-and-fro over the surface of the transmitting apparatus. While the magnetizing current continued to flow, a similar point traced a continuous line on the receiving surface, but whenever a break occurred, as, for example, by the non-conducting ink, the point was drawn away by a spring. The successive makes and brakes so obtained produced on the receiving cylinder the design traced on the transmitter.

Hitherto, the various systems of fac-simile transmission have failed in their successful commercial applications, either because of their unreliability or from their great expense. When a single stylus or pencil was employed, as in the system of Bakewell Caselli and others, the method was slow in operation and unreliable in its results. Bonelli's introduction of a multiple comb or stylus, in which a series of styluses or fingers at each station were employed, connected between the two stations by a cable containing as many single conducting wires as there were fingers in the compound stylus at each station, increased the speed of transmission.

Bonelli's system, as will be readily understood, was a great improvement on the systems known at the time of its invention. Two difficulties, however, existed which have prevented its extensive use. These were, 1st, the great expense of construction when the cable connected two distant stations, and 2d, the unreliability in the results attained, owing to interferences in the strength of the momentary impulses sent through the separate wires of the cable, by induction in or by neighboring wires.

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Mr. Delany has happily applied his system of synchronous-multiplex telegraphy to fac-simile transmission and has attained results that appear to render the actual commercial application of fac-simile telegraphy practicable. His system briefly consists in dividing a single telegraph wire, connected at each of its ends to a multiple comb, or series of styluses, into as many separate and practically distinct lines as the separate and distinct styluses at either end. The division of the single connecting wire into a number of separate lines is effected by his system of synchronous multiplex telegraphy, now so generally understood.

The means, whereby this application is made, will be better understood by an examination of figure 1, for which, in common with all the figures used in this paper, the author is indebted to the United States Letters Patent, granted to Mr. Delany for fac-simile transmission. In Fig. 1, is shown the transmitting and receiving apparatus connected with the synchronous distributer. In this figure *X*, and *Y*, are the two stations. *A*, is the rotating disc, and *a*, its trailing finger or circuit completer, mounted on the axis of the disc *A*. *B*, is the circular table of insulated contacts. Eighty-four of these contacts are provided in this case, divided into six series of fourteen each.

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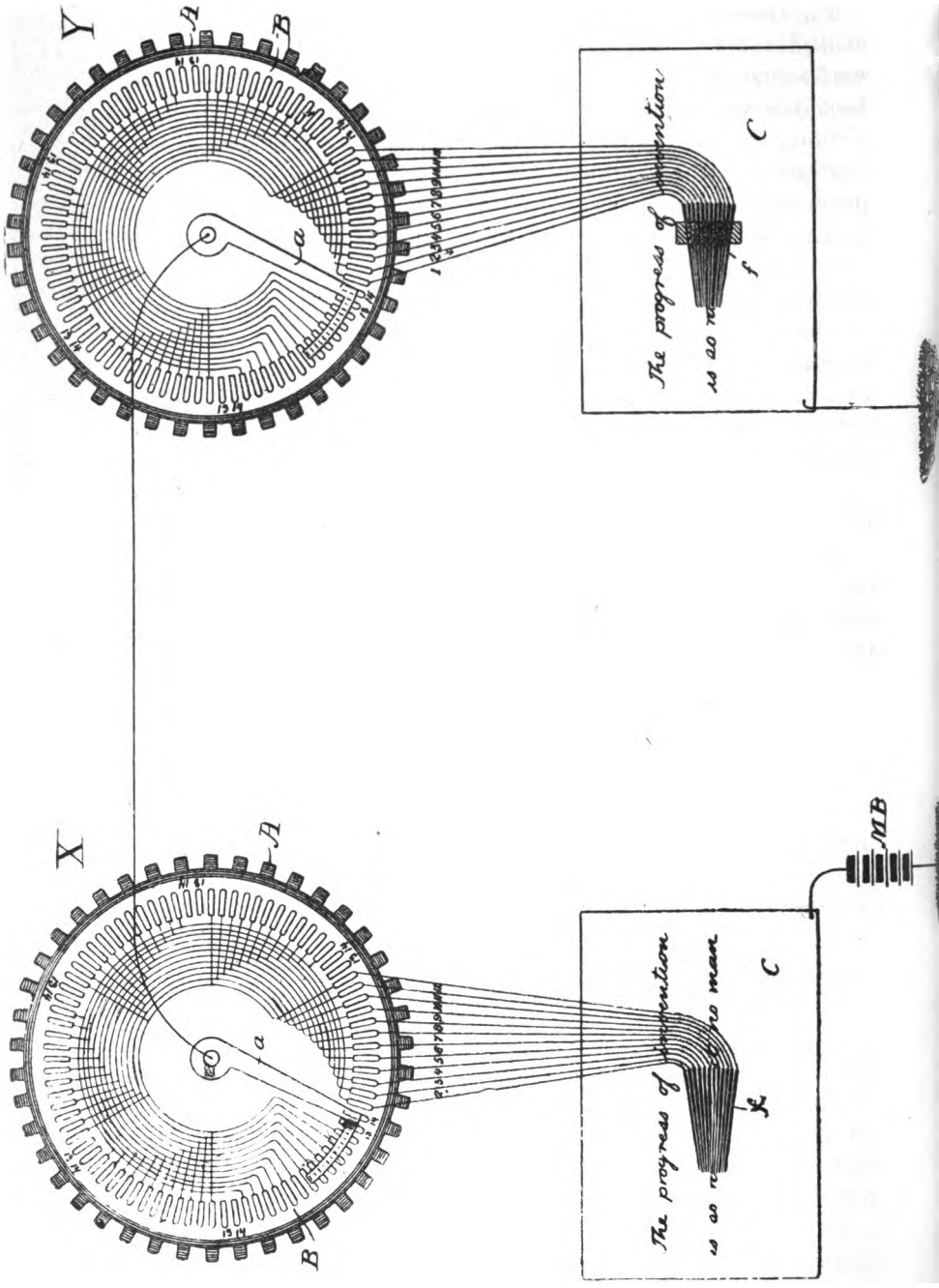

FIGURE 1, DELANY'S FAC-SIMILE APPARATUS.

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The 13th and 14th contacts in each of these series is not shown as connected in the figure, these contacts being reserved for the synchronous correction of the apparatus, in accordance with the Delany synchronous multiplex system.

Supposing the contacts in each of the six groups to be numbered from 1 to 14 consecutively, the number-one contacts in each of the six groups are connected together and to a line marked 1, at station *Y*, and the corresponding contacts similarly connected at station *X*, to a line marked *X*. The number-two contacts at each station are similarly connected to one another and to a line marked 2, and so with the other contacts, the 13th and 14th in each of the groups being reserved for the sychronizing of the line as already explained.

Each of the lines 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, so provided, is connected to an insulated finger or stylus *f*, that forms part of a comb that moves over the surface of the transmitting and receiving instruments *C*, *C*.

When now the synchronously moving fingers *a*, *a*, move over the contacts, they simultaneously rest on similar or corresponding contacts at each end of the line, thus completing the circuit from the insulated finger *f*, in said circuit 3, at station *X*, with the insulated finger *f*, in circuit 3, at station *Y*.

If the trailing fingers are rotated at a speed of say three times per second, the circuit will be completed over each of the twelve lines so provided between the two stations, eighteen times a second. At this rate a high speed of transmission is attainable. The insulated fingers are arranged, as shown in the figure, on a comb in close proximity to one another, but separated by some good insulating material. The plates *c*, *c*, on which these fingers rest, are maintained in approximately synchronous motion by clock-work or other suitable mechanism.

The battery *M B*, at one of the stations as *X*, has one of its poles connected to ground and the other to the metallic plate *C*. Let us suppose now that *X*, is the transmitting station and *Y*, the receiving station, and that the message to be transmitted is written on the surface of *C*, at *X*, in some electrical non-conducting ink, while the surface of the receiving apparatus at *C*, is covered with a sheet of Bain or chemically prepared paper.

When now the ends of the fingers *f*, at *X*, are in direct contact with the metallic plate, the circuit of the battery *M B*, will be independently completed through each of the twelve lines, eighteen

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times per second through the fingers at Y, to the ground, and will thus produce the well-known blue marks or lines on the paper at that station. When, however, the circuit is broken by the trailing finger at X, coming in contact with the insulating ink, the otherwise continuous line marked on the paper at Y, will appear broken, no discoloration appearing at such point. Whatever therefore is traced on the transmitting surface is automatically reproduced on the receiving surface in white lines on a nearly continuous blue ground.

Although any series of points in a straight line in the design traced on the transmitting surface, that were simultaneously touched by all the twelve separate and independent fingers, would not be actually reproduced on the surface of the receiving apparatus as a rigorously straight line, since the electrical impulses would not be simultaneously sent over all the lines but over each in succession, yet in actual practice the completion of the circuits in each of the separate lines occurs at such frequent intervals, that the deviation from the straight line in the case supposed is not discernible, and the effect is the same, as if the corresponding fingers at the two stylusses were actually connected by separate and independent main lines.

In figure 2, are shown some of the details of the multiplex stylus or comb with its trailing fingers.

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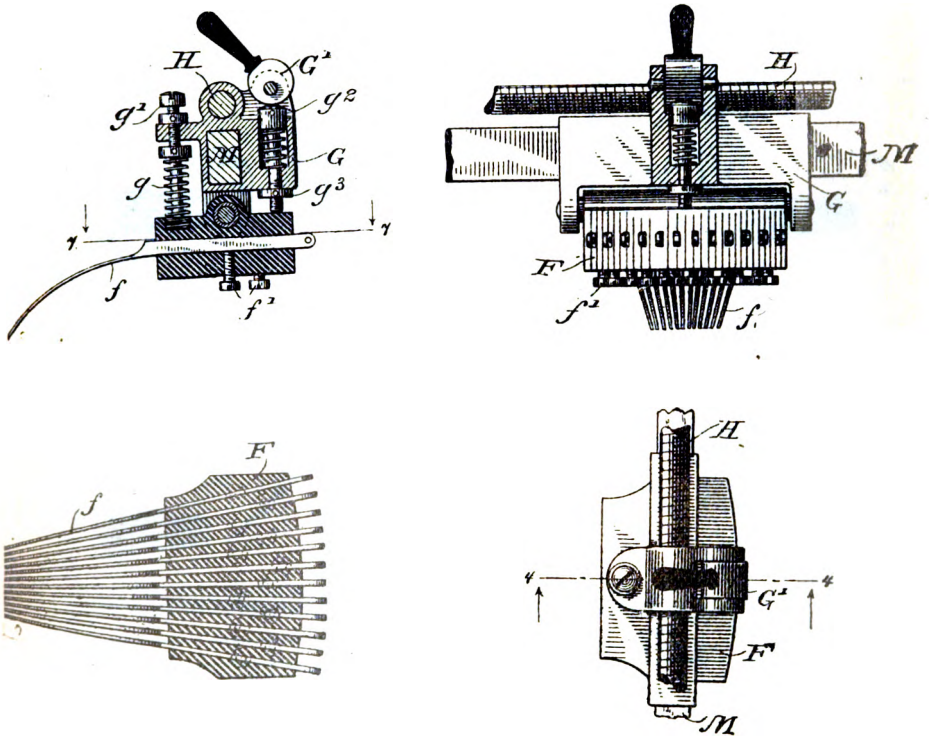

FIG. 2. DETAILS OF MULTIPLEX STYLUS OR COMB.

The separate fingers f, are mounted in the insulating block F, by being pressed through slots or apertures in said block. Set screws f^1, are provided for holding the fingers in position and for permitting their adjustment. The block F, pivoted at G, moves over the screw threaded shaft H. A spring g, adjustable by g^1, keeps the stylusses pressed against the surface of the metallic plate C. The depression of the trailing finger is limited by the bolt g^2, and its collar g^3, in the manner shown.

The cam G^1, is provided for pressing down the bolt g^2, so that when C, has reached the end of its motion, the fingers may be held away from the plate C, while it is being drawn back again into position.

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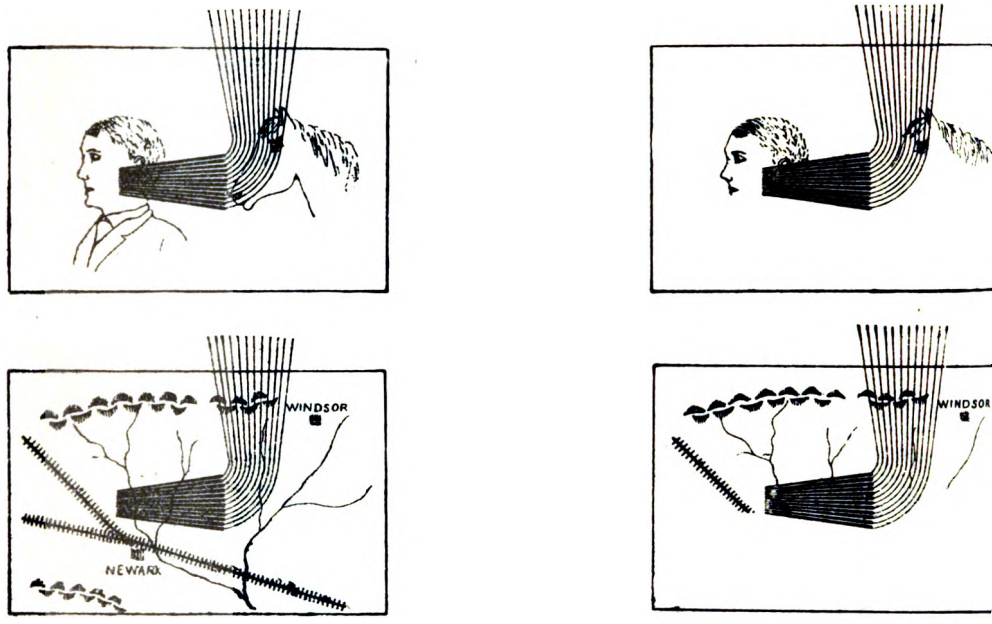

FIG. 3, FAC-SIMILE TRANSMISSION.

In figure 3, is shown the fac-simile transmission of a drawing and of a map. The transmitting station is on the left of the drawing, the receiving station on the right.

Any method may be adopted for the motion of the movements of the transmitting and receiving surfaces *C*, *C*. Mr. Delany has shown a number of such devices in his United States Letters Patent. In figs. 4, 5, and 6, are shown the details of a device suitable for obtaining a reciprocating motion of the plates *C*, *C*. The frame of the instrument is shown at *I*. The plate *C*, is driven by a rock C^4, actuated by any ordinary clock-work *K*. A screw shaft *H*, has its bearings on the lugs or vertical standards *I*, situated as shown. The comb is carried by the frame *G*, which moves laterally on the string-bar *M*, connecting the standards *L*, *L*, as the shaft *H*, is rotated.

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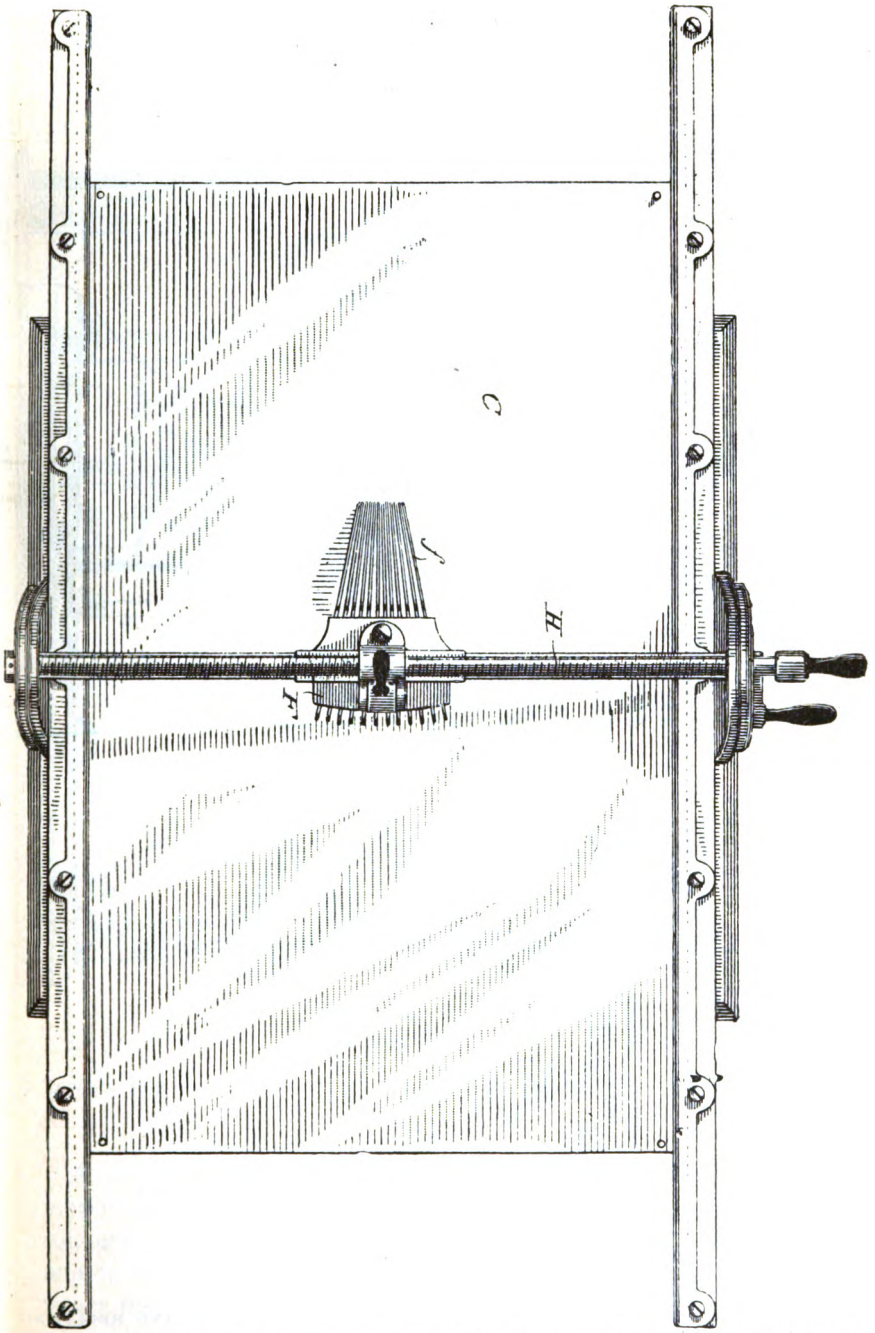

FIG. 4, FOR RECIPROCATING MOTION OF TRANSMITTING AND RECEIVING APPARATUS.

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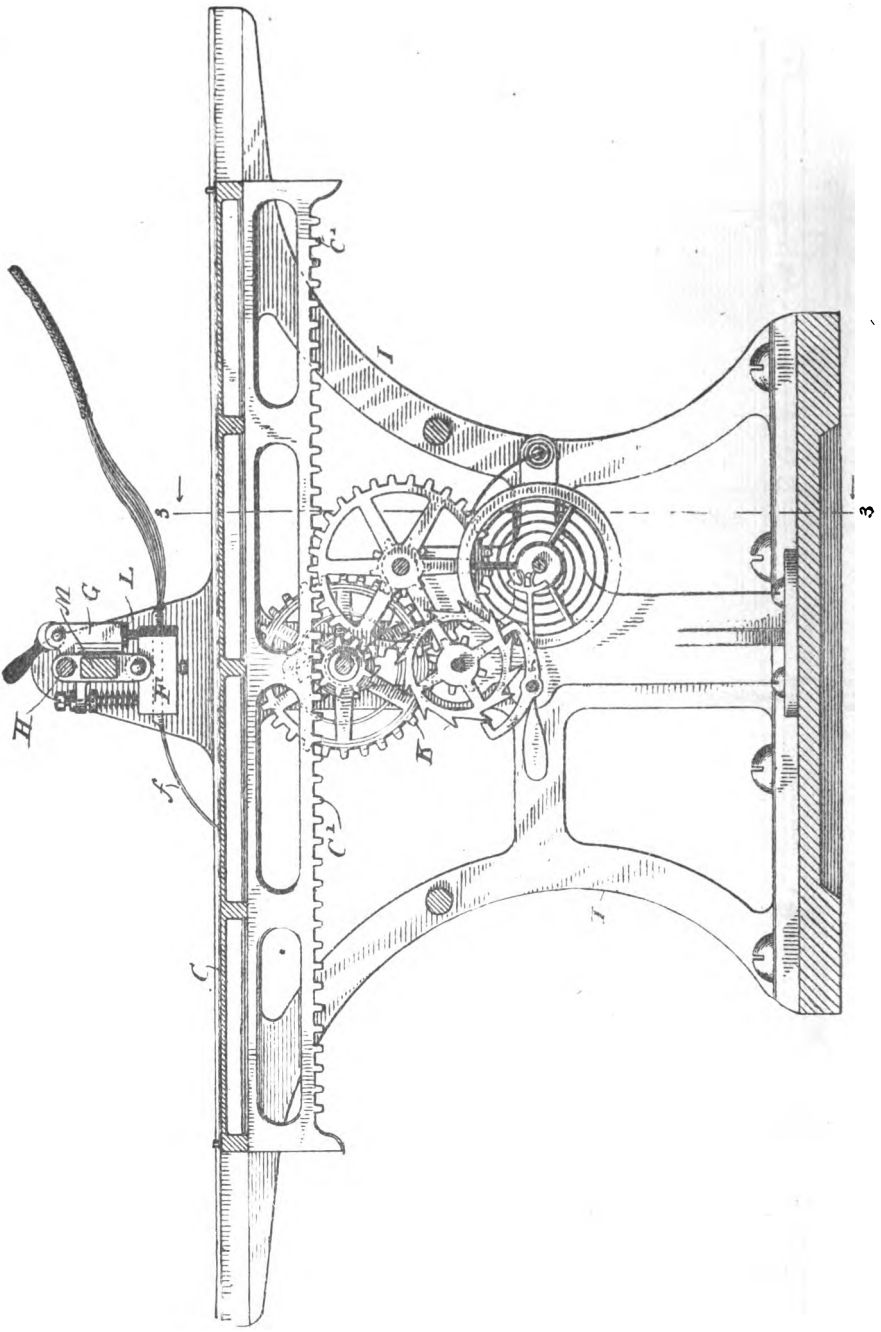

FIG. 5, DEVICE FOR RECIPROCATING MOTION OF TRANSMITTING AND RECEIVING APPARATUS.

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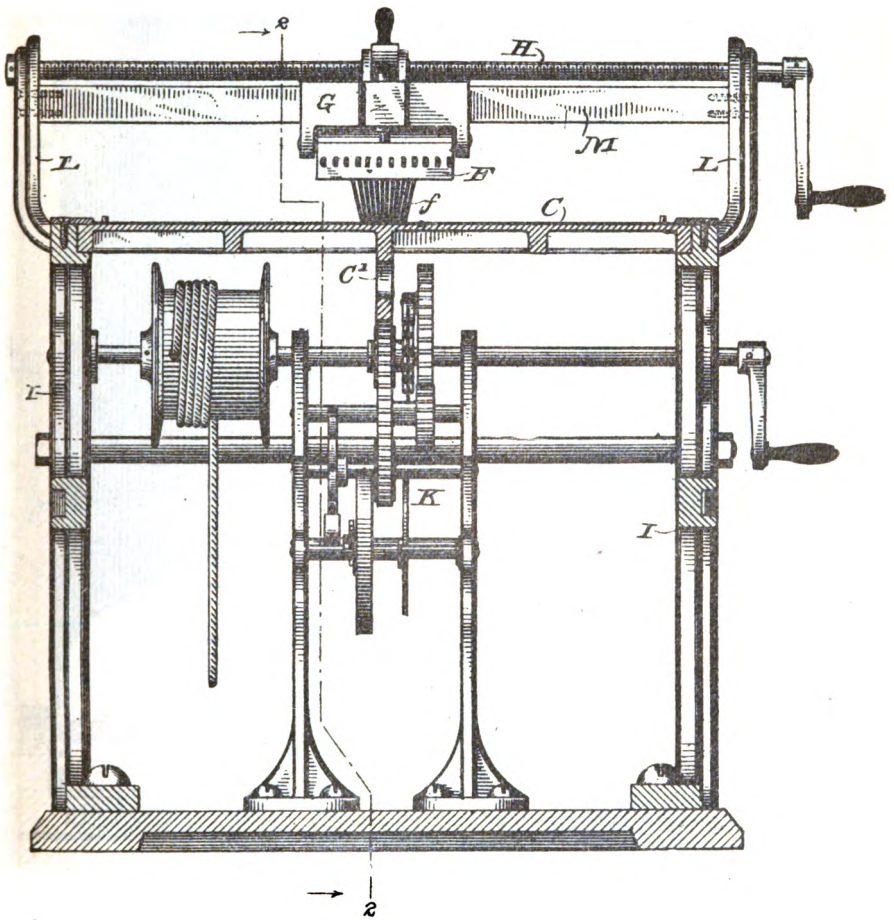

FIG. 6, DEVICE FOR RECIPROCATING MOTION OF TRANSMITTING AND RECEIVING APPARATUS.

A much neater and more practical method for obtaining the motion of the transmitting and receiving apparatus is shown in connection with Figs. 7, and 8. In this form the reciprocating motion of the preceding apparatus is replaced by a continuous rotary motion of the plate as will be explained.

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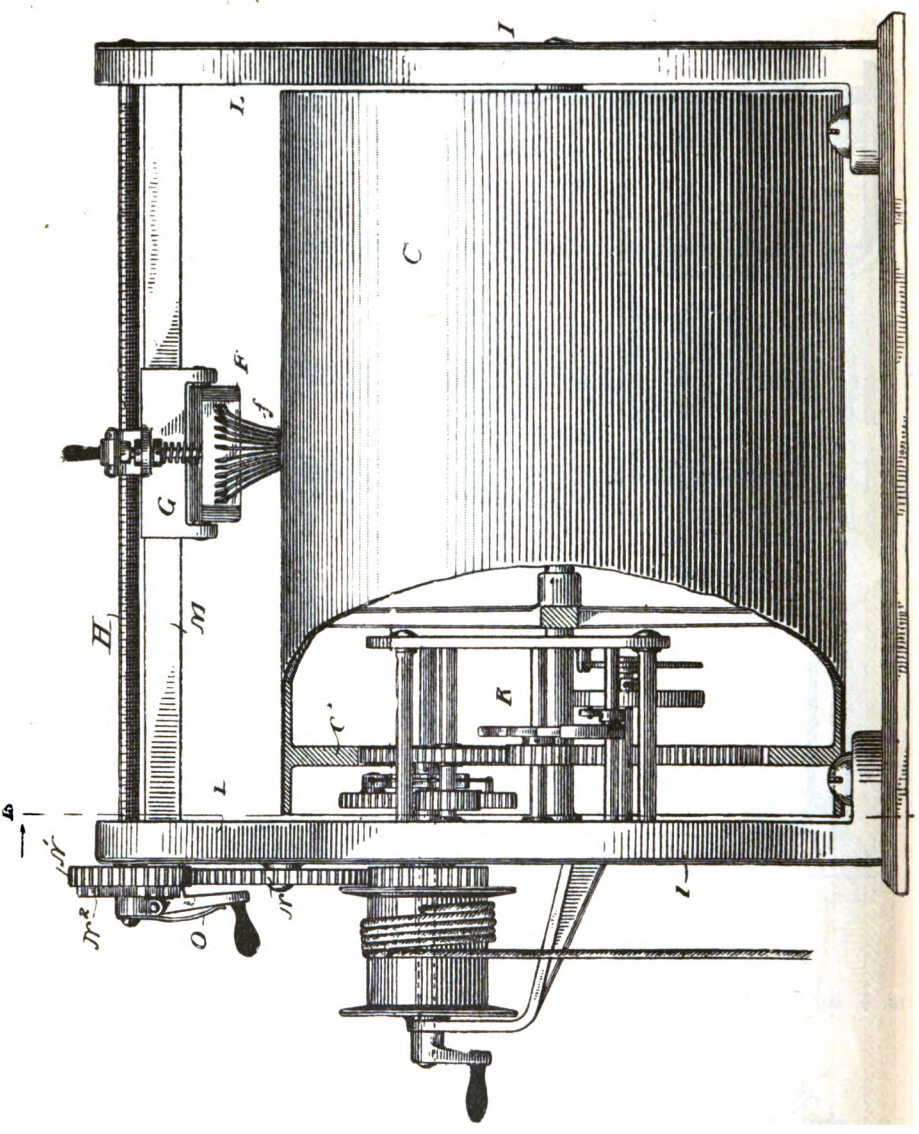

FIG. 7, DEVICE FOR ROTARY MOTION OF TRANSMITTING AND RECEIVING APPARATUS.

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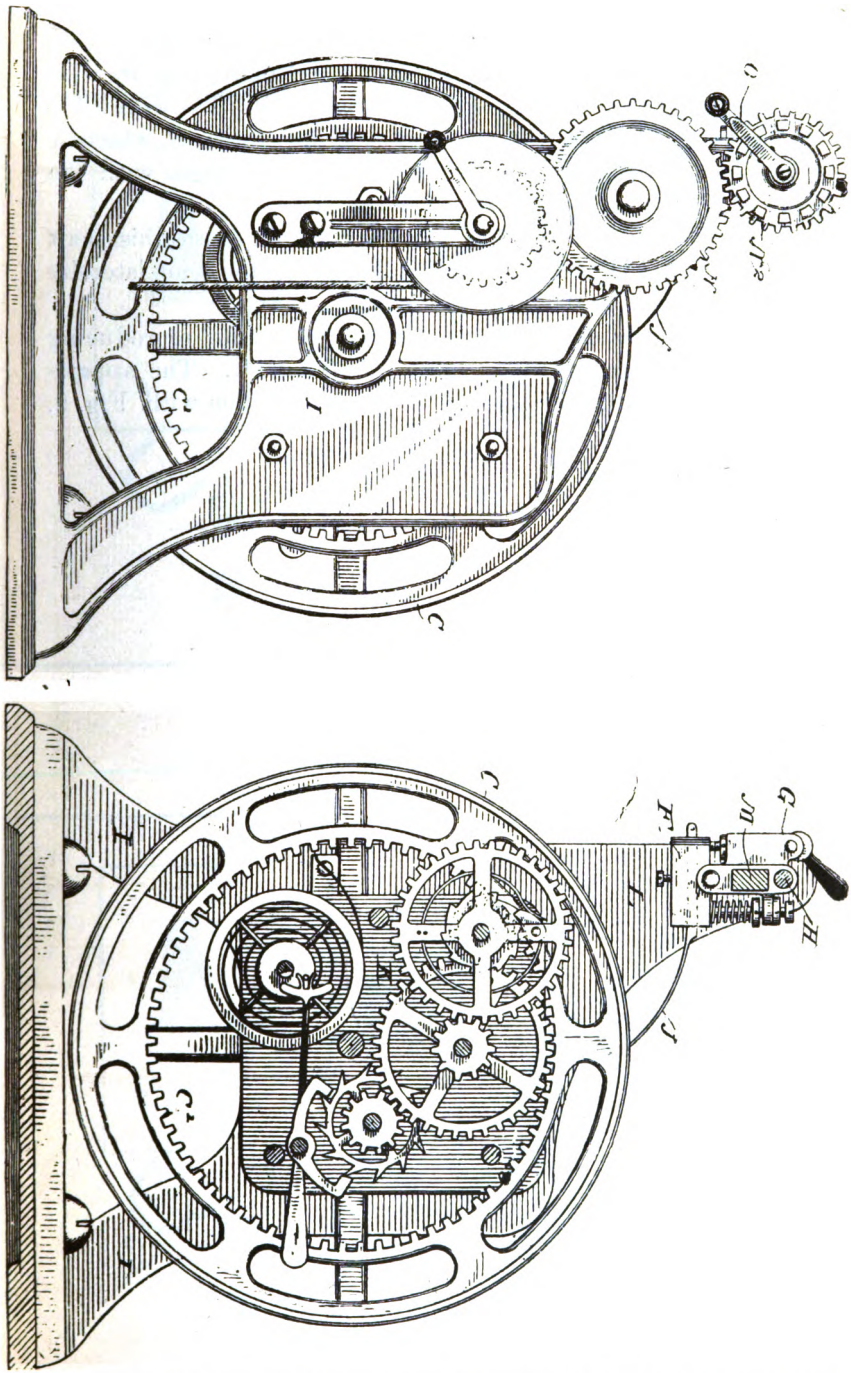

FIG. 8, DEVICE FOR ROTARY MOTION OF TRANSMITTING AND RECEIVING APPARATUS.

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In this form of apparatus a rotary cylinder *C*, replaces the plate *C*, *C*. "The gear wheel *N*, driven from the clock-train, gears with a wheel N^1, which is loose on the screw-shaft *H*. The wheel N^1, is normally locked on the shaft by a spring catch, *O*, which is pivoted in a collar on the end of the shaft and engages with the teeth of a gear-wheel, N^2, fast on the shaft."

The locking of the wheel N^1, on the shaft *H*, causes this shaft to move as the cylinder is rotated, and so moves the comb laterally over the cylinder as the latter revolves.

Mr. Delany has devised the following means for reproducing the fac-simile despatch by means of a local battery. The apparatus required for this purpose is shown in connection with. Fig. 9.

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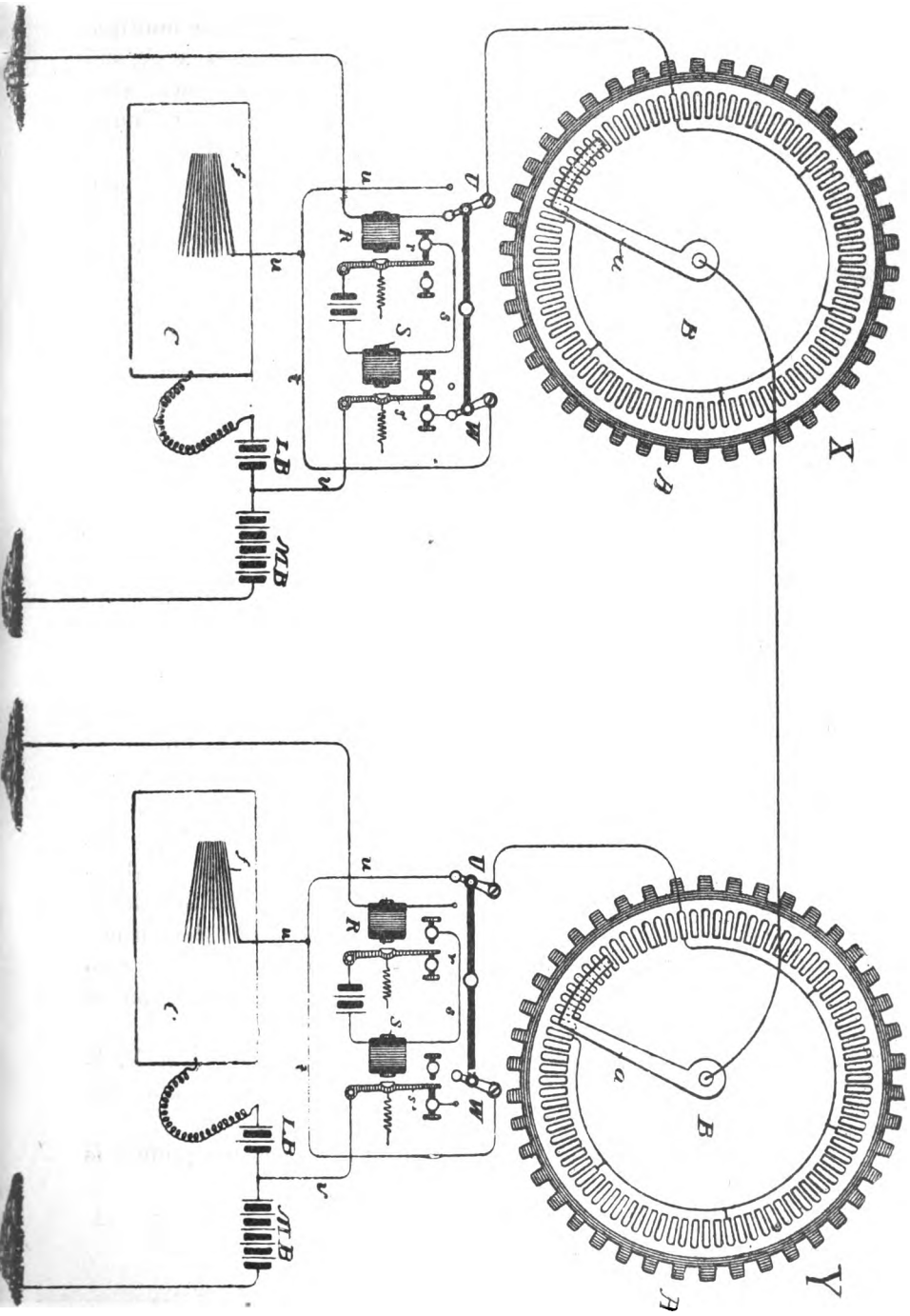

FIG. 9, FAC-SIMILE REPRODUCTION BY LOCAL BATTERY.

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In this drawing only one stylus in the comb *f*, is represented as connected in the circuit for the purpose of avoiding the multiplication of unnecessary lines. The local batteries *L B*, at *X*, and *M B*, at *Y*, the transmitting station, connected as shown, send their current through the plate *C*, finger of the comb *f*, line *u*, switch *U*, to the table of circular contacts on *B*, and thence to the main line; the local circuit *t*, and the branch *v*, being both open.

At the receiving station *X*, the switch *U*, is connected with the coil of the relay *R*, and *W*, in connection with the back-contact of the armature s^1, of the magnet *S*. When the current that passes over the main line from *Y*, flows through the electro-magnet *R*, it energizes its core and attracts the armature and draws it against its front stop. Since the transmitting battery at *Y*, is sending its impulse into the main line at the rate of about eighteen per second, the armature of *R*, has no time to leave its front stop and is therefore constantly drawn against it, thus completing the local circuit *s*, of the magnet *S*, and drawing its armature s^1 against its front stop.

Suppose now the receiving surface at *C*, is covered with a sheet of Bain paper, and that a message is written in non-conducting ink on the transmitting surface at *Y*, then as long as the main current is passing over the main line at the rate mentioned, no marking will be produced on the receiving surface at *X*. When, however, the trailing finger *f*, comes in contact with the non-conducting line traced on *C*, at *Y*, the battery current over the main line is interrupted for a sufficient length of time to permit *r*, under the action of a spring, to come against its back-stop, break the circuit *s*, and permit s^1, to move against its back-stop. Under these conditions, the circuit of the local battery *L*, *B*, will be completed through the receiving plate *C*, as follows: viz, from the battery through *C*, "finger *f*, line *ut*, switch *W*, armature s^1, line *v*, to the opposite pole of the battery;" and thus effect a coloration in the paper covering the plate *C*.

In this manner the design traced on the surface *C*, at *Y*, is reproduced in colored lines in the otherwise white surface of the paper that covers the surface of the receiving apparatus.

The form of apparatus, however, which Mr. Delany prefers is shown in connection with Fig. 10.

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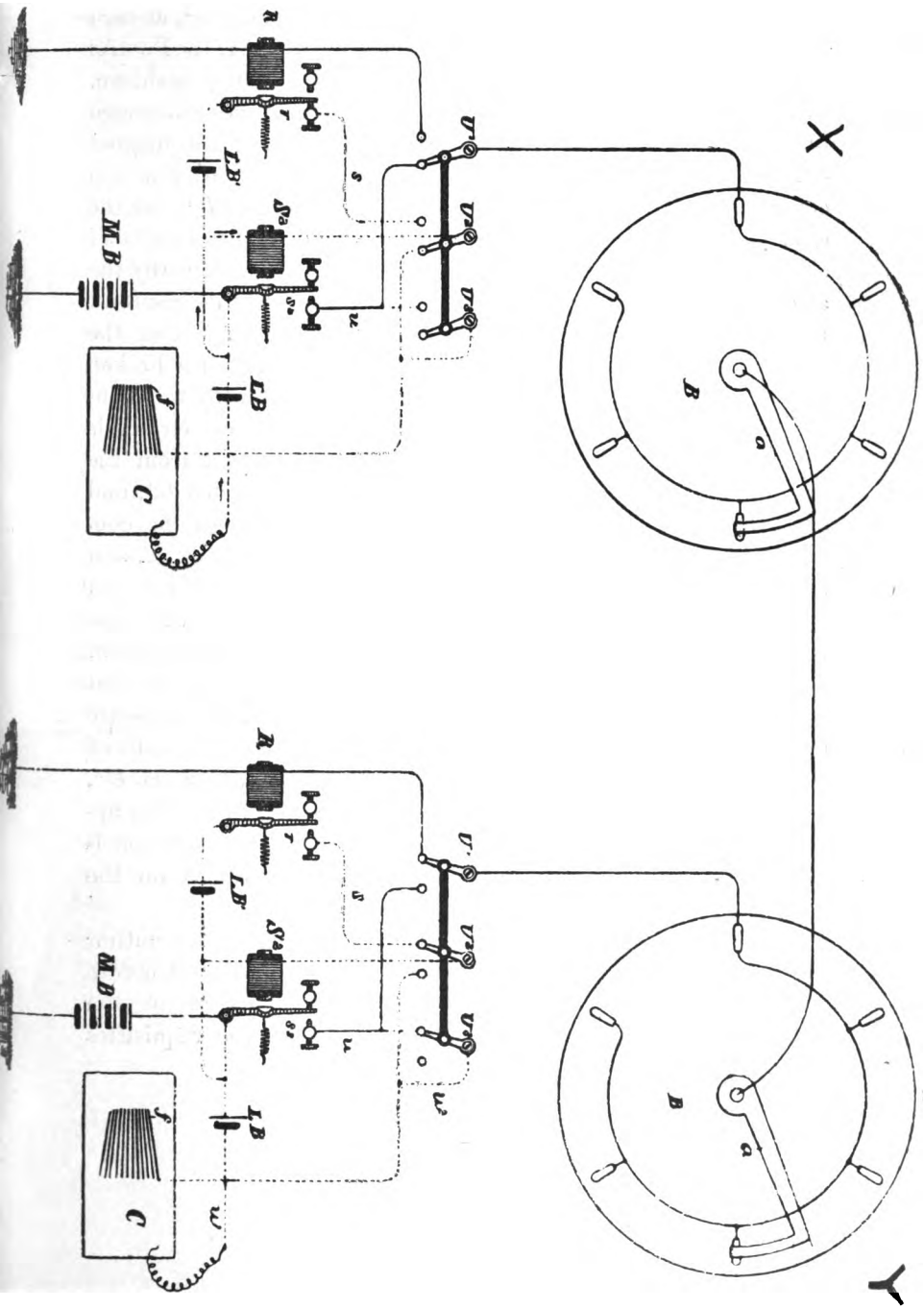

FIG. 10, FAC-SIMILE TRANSMISSION ; IMPROVED APPARATUS.

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As shown in this figure the switches U^1, U^2, and U^3, at each end of the line are arranged for transmission from X, to Y. As before, connections with a single group of contacts only is shown.

The transmitting battery M, B, has one of its poles connected to ground and its other pole to the armature s^2, of the magnet S^2. The front stop of this armature is insulated; its back-stop is connected to the main line, through the line u^1, switch U^1, and the circular table of contacts. The local battery L, B, has its circuit closed under normal conditions through the path indicated by the arrows. The armature s^2, is therefore drawn against its insulated front stop, whenever the circuit between the finger f, and the plate C, is uninterrupted. When, however, this circuit is broken or interrupted by the finger f, coming in contact with the non-conducting ink on transmitting surface at X, this local circuit is interrupted, s^2, moves to its back-stop and the current from the main battery M, B, will pass through the line u^1, switch U^1, and over the main line to Y, when, after passing through the contacts and the switch U^1, it flows through the coils of R, and thence to earth. The armature r, of magnet R, is thereby drawn against its front stop, thereby breaking the circuit of the local battery L, B^1, which normally is completed through armature r, line s, switch U^2, and magnet coil S^2. When the impulse sent from X, breaks this circuit in the manner described, the armature of S^2, moves against its back-stop, thus completing the circuit of the local battery L, B, through the armature s^2, line u^1, switch U^3, u^2, f, and plate C. If, therefore, the surface of the receiving apparatus is covered with a sheet of Bain paper, a discoloration is produced thereon, which reproduces the design traced on the transmitting apparatus.

From this brief description of the apparatus which the author has drawn mainly from the United States Letters Patent before referred to, it will readily be seen that Mr. Delany has produced a system of fac-simile telegraphy that possesses all the requisities for successful commercial application.

CENTRAL HIGH SCHOOL,
Philadelphia, May 18th, 1885.

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TRANSACTIONS

OF THE

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OF

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VOL. III.

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AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

Annual Meeting.

May 18th, 1886.

The meeting was called to order at 8 P. M., May 18th, 1886, by Vice-President Frank L. Pope, in the rooms of the American Society of Civil Engineers, 127 East 23d Street, New York city.

The Chairman: The first business before us this evening is the election of officers for the ensuing year. I will ask the Secretary to read the list of candidates.

The Secretary: The by-laws regarding the election of officers were amended and simplified at the meeting held December 7th, to read as follows: "Elections: The annual election shall be held in the city of New York, on the third Tuesday in May of each year. Nominations for officers may be made in writing to the Secretary at any time previous to the meeting, but the votes shall be by ballots deposited only by members actually present. *Provided*, that no member or associate in arrears since the last annual meeting shall be allowed to vote until the said arrears shall have been paid. If for any reason it is deemed proper to postpone the election, it may be adjourned from day to day with the consent of two-thirds present or voting. Referring to the terms of office—

Section IV provides: "The President, the Secretary, and the Treasurer for one year (and no person shall be eligible for immediate re-election as President, who shall have held the office subsequent to the adoption of these rules, for two consecutive years), the Vice-President, for two years, and the Managers for three years; and no Vice-President or Manager shall be eligible for immediate re-election to the same office at the expiration of

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the term for which he was elected. At each annual meeting, a President, three Vice-Presidents, four Managers, a Secretary and a Treasurer shall be elected, and the term of office shall continue until the adjournment of the meeting at which their successors are elected."

It will be seen according to the by-laws, the President of the Institute, Dr. Norvin Green, is ineligible for the office of President, having held that office for two terms, and consequently the nominations for President will be first in order. There have been no formal nominations made.

THE CHAIRMAN: We are now ready to receive nominations for President for the ensuing year.

MR. MAILLOUX: I would like to make a nomination, and in rising to make that nomination I think it is proper perhaps to make a few remarks as to what the character of a nominee for President should be—what is the kind of man that we would like to have as a President. I have been connected with a few scientific and semi-scientific societies, and it has been my experience and my observation that a great deal of the success or non-success of an institution depends on the head of it. I remember some societies with which I have been connected that have been successful at certain periods of their life, and merely because they have had a man at their head who understood the nature of the position, who was so intimately associated with the objects of the association that he could see to the wants of it. I need not say, of course, that it is useless for us to have a President who is not a President except in name. I think after a few years of that kind of head-ship and leadership the society will suffer greatly. Now the man that I would specially favor—I have several names, all of which would be acceptable to me but there is one of them that I think ought to come first, a man who has won his spurs, as my friend Mr. Jones was just telling me; a man who would lend dignity and grace and force to the Institute, because he is so associated with electricity that when his name goes out as President of this Institute the whole electrical world will know him. I have reference to Mr. Frank L. Pope.

MR. PHELPS: I second the nomination very heartily.

I move further that the Secretary be instructed to cast the ballot of the association for the nominee. That will save the trouble of passing around the hat and cutting up pieces of paper.

THE SECRETARY: There certainly can be no objection to the

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election taking place now. It was my idea that if we went through these nominations and postponed an election until later in the evening, it would give a chance for others to come in and it could not be said that we finished up too soon for them. There are several other nominations to come up, and we might make all the nominations and vote on them afterwards.

MR. PHELPS: I will withdraw my motion.

THE SECRETARY: There are to be three Vice-Presidents elected in the place of Messrs. T. A. Edison, George A. Hamilton, and Prof. A. E. Dolbear. It has been very properly suggested by our Treasurer, Col. Hazard, that although Dr. Green is inelegible for the presidency, it would be a very proper compliment to make him a Vice-President, and in the absence of Col. Hazard I would nominate Dr. Norvin Green as one of the three Vice-Presidents.

MR. PHELPS: I second the nomination.

Mr. WETZLER: I would like to put in nomination Mr. C. O. Mailloux.

The nomination was seconded.

MR. MAILLOUX: I think that kings should come before princes always, and there are lots of other men who would grace the position much better than I. I am willing to wait until I grow a little. If I may be permitted to put a name in substitution I would nominate Mr. Frank W. Jones as Vice-President.

THE SECRETARY: Mr. Jones is already a Vice-President.

MR. MAILLOUX: All right. I will put in another one. I do not think there is a better name than Mr. T. D. Lockwood.

THE CHAIRMAN: Do I understand you to decline the nomination, Mr. Mailloux?

MR. MAILLOUX: Yes, sir.

MR. LOCKWOOD: It is rather an equivocal compliment of Mr. Mailloux to say that he resigns in favor of an older man, but since he qualifies that by comparing me to a king and is content himself to be a prince, I do not know but that I will consent to have my name placed in nomination.

THE CHAIRMAN: There is one other nomination to be made for Vice-President, and I would suggest that as we have one from New York, Dr. Green, and Mr. Lockwood, from Boston, that it would be very well to represent some other part of the country, the South or West, in one of the other nominations.

MR. LOCKWOOD: Mr. President, I nominate Mr. George C. Maynard of Washington.

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THE SECRETARY: I second the nomination. I was about to make it myself. There are three nominations now made for the vice-presidency. Unless some one wishes to run a dark horse for another candidate, that will be a sufficient number of nomitions.

MR. LOCKWOOD: Will the Secretary be so good as to read the names of the Vice-Presidents who do not retire?

The SECRETARY: Frank L. Pope, who will retire if he is elected President, D. H. Bates, and F. W. Jones.

MR. MAILLOUX: Do I understand you to say that there will be another one if Mr. Pope is elected President?

The SECRETARY: There will then be another vacancy.

MR. MAILLOUX: I understood that there had been a movement to introduce some physicist into the chair of President, and although I was somewhat opposed to that, thinking that we should have a practical man at the head of things, still I have in mind several men who occupy professorships in the different colleges who would be a great honor to a position either as President or Vice-President, and above all I think we should not forget a man of the standing of Prof. Anthony of Cornell, and especially so from the fact that he is connected with the School of Electrical Engineering there. He is a man who has done a great deal for the science and he is a man who stands quite high, and if there is a vacancy I think it would be well to bear in mind that name before we take others.

The nomination was seconded.

THE SECRETARY: There are four Managers who retire at this election; Prof. Trowbridge, Prof. Gray, Theodore N. Vail, and W. D. Sargent.

MR. JONES: I would beg to nominate Mr. Mailloux as one of the Managers.

The nomination was seconded.

THE CHAIRMAN: We should have at least three other nominations.

THE SECRETARY: I am well aware of the importance not only of the Institute being represented in New York, but of its being well represented in New York, and when I say represented I mean actively represented. Such being a very desirable feature in a board of officers, I would respectfully nominate Mr. Sidney F. Shelbourne of New York as one of the Managers.

The nomination was seconded by Mr. Lockwood.

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MR. JONES: Will you have the kindness to have the list of Managers read that are not to retire.

THE SECRETARY: Charles F. Brush, Prof. Edwin J. Houston, Edward Weston, C. L. Buckingham, David Brooks, G. M. Phelps, Jr., Prof. B. F. Thomas, T. C. Martin.

I do not care to do all the nominating, Mr President, but there will be a gentleman here to-morrow, if he is not this evening, who took a good deal of trouble to attend our last special meeting and did most efficient work as presiding officer, and in his suggestions in the amendment of the by-laws. He is a man who stands high in engineering circles and a member of the American Society of Civil Engineers to which we owe so much. He is a man whose reputation dates back at least a quarter of a century. I refer to Capt. O. E. Michaelis of the Watervliet Arsenal at Troy, who I place in nomination as a Manager.

The nomination was seconded.

MR. SHELBOURNE: I nominate Prof. Brackett of Princeton College as a Manager.

The nomination was seconded by Mr. Wetzler.

THE CHAIRMAN: That completes the list of nominees equal to the number of vacancies. Of course we are at liberty to receive as many more as are offered.

MR. PHELPS: Is it in order, Mr. Chairman, to make a nomination for Secretary.

THE SECRETARY: Yes, sir. The Secretary and Treasurer are elected every year.

MR. PHELPS: Then I nominate Mr. Ralph W. Pope as Secretary.

The nomination was seconded by Mr. Lockwood.

MR. PHELPS: I do not think we can do better than re-nominate our present Treasurer, Mr. Hazard, and as I see no other nomination offered, I make that.

The nomination was seconded.

On motion of Mr. Jones, it was voted that the nominations be closed.

MR. PHELPS: Will the chair be good enough to have the entire list of nominees read.

THE CHAIRMAN: The Secretary will please read the list of nominations.

THE SECRETARY: The nominations are: For President, Frank L. Pope; for Vice-Presidents, Dr. Norvin Green, Thomas D.

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Lockwood, George C. Maynard, W. A. Anthony; For Managers, C. O. Mailloux, Sidney F. Shelbourne, Capt. O. E. Michaelis, Prof. C. F. Brackett; for Secretary, Ralph W. Pope; for Treasurer, Col. Rowland R. Hazard.

Mr. Lockwood: I have a word to say before we proceed to any other business in regard to an observance which is followed in many other organizations of this character, as also in secret organizations. The one I have chiefly in mind is the analogous society, the London Society of Telegraph Engineers and Electricians. It is customary on the retirement of the President to place him on something like a retired list with the title of Past-President. I do not think there is any constitutional or legal provision for such an arrangement, but on the other hand I do not believe there is any constitutional or legal obstacle to it, and I think it would be a becoming honor not only for our present retiring President, but for any other who shall come after him, to give him such honorary rank and to place his name and title on the list of officers of the Institute in that capacity.

The Chairman: I think that is a very excellent suggestion of Mr. Lockwood's.

Mr. Jones; I quite accord with Mr. Lockwood's views on this subject. It had not occured to my mind before when we were making our Past-President a Vice-President. I think it is true that in some societies, both secret and otherwise, a man sometimes steps from the chair and becomes door-keeper; but this is hardly in that direction and it looks to me wise. It has worked well so far as the English society is concerned. I think that when the President retires that the year in which he serves the society should be printed in our journal and he should be classed as a Past-President of such a year, and as has been remarked there is no disability and no constitutional provision to the contrary and in the face of that I think we could carry that out. I approve of it.

The Chairman: It would probably be sufficient if are solution were passed authorizing the names of retiring Presidents to be printed as Past-Presidents in all the publications of the Society in which the officers names appear.

Mr. Lockwood: It might be well then, if it be the will of the society that some one, myself perhaps, as I made the suggestion, should draw up a written resolution and offer it to the Institute at the present meeting.

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THE CHAIRMAN: I think it would be be well to do that and when the other business is finished we could bring the matter up.

MR. SHELBOURNE: I concur with the suggestion very heartily, Mr. Chairman, but in looking at it as a matter which involves a title in the printed publications of the Society it seems to me as a legal point that it ought to be provided in the by-laws that all Past-Presidents should be so named in the publications of the Society, etc. I only make that as a suggestion. There is that doubt in my mind about the propriety,—I mean the formal propriety, of adopting such a resolution without it becomes at some time a part of the by-laws.

MR. PHELPS: If it be in order to go on with the election, as I suppose it is, I would move now that the Secretary be directed to cast the vote of the Institute for the entire list as read. I believe that course is entirely proper where it is not objected to. It can be voted down if people object to it, and it saves time.

MR. JONES: It has been suggested that if we are to fill the vacancy that is to be caused by Dr. Green's withdrawal, that steps be taken to re-arrange our by-laws so that in course of time Dr. Green can be placed on this list so as not so do any violence to our constitution. Perhaps the gentleman who has made the suggestion will make a motion to that effect.

THE SECRETARY: Mr. Chairman, it does not occur to me that there is any violation of the by-laws by a resolution of this character. It appears to me that if a compliment is intended, that a special compliment in the way of a resolution to the retiring officer would be more proper than a compliment to which he was entitled by the regular routine of the by-laws.

MR. LOCKWOOD: That was entirely my idea. I had no thought whatever of, as it were, taking away the vice-presidency from Dr. Green. I think the Doctor is quite competent to be a Vice-President and a Past-President both at the same time. If the fact that he is a Past-President will render him ineligible for future office, I, of course, shall withdraw my resolution. I think he is quite competent to hold both offices and at the same time no by-law will be necessary.

MR. PHELPS: It had not entered into my consciousness that it was intended to withdraw Dr. Green from the list of Vice-Presidents and we ought to remember that this is a title and not

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an office. As it is not an office, in any sense, I think it is very plain that it is in order for us by mere resolution to authorize this title.

THE CHAIRMAN: I do not understand that this would render Dr. Green ineligible to office or affect that question in any way. Perhaps it might be well to suggest that the resolut on might be offered in respect to Dr. Green personally and that at the same time the same resolution or another might be offered looking to the amendment of the by-laws or to an addition to the by-laws of a provision whereby all the ex-Presidents will be placed on the list of Past-Presidents.

MR. SHELBOURNE: There was no such idea in my mind at all that giving the retiring President a complimentary designation of Past-President would make him ineligible to office. It was merely a question as to the formality of such a resolution. It is true that while the by-laws say nothing about it, they also say nothing for it, and we are governed here by a constitution and by-laws. Of course if this is intended for the time being merely for a compliment to the retiring President, and such a compliment may or may not be paid to any other successor of the President, why then I should say that it was a mere matter of the present resolution, and it does not effect the question as to whether the by-laws do provide for it or whether they may provide for it. I merely made my remarks as casting out a suggestion and expressing a doubt without any view of formal action that I should have to propose in regard to it.

Regarding the motion of Mr. Phelps, as to casting the ballots for all the nominations by one as a committee, I would say that there seems a technical objection to that procedure so far as the nominee for President is concerned, because the nomination for one of the Vice-Presidents, I think, must necessarily be only contingent, and that nomination cannot stand or be acted upon until the President is formally elected. Therefore, I think, if Mr. Phelps would amend his motion so that a vote might be cast as one for the President and then afterwards, a vote for all the other nominations may be cast in the same manner.

MR. PHELPS: I accept Mr. Shelbourne's suggestion and would amend my motion by moving that the Secretary be instructed to cast the vote of the Institute for Mr. F. L. Pope for President.

THE CHAIRMAN: Before putting that motion perhaps it might

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be well to see what the provisions are in the constitution or by-laws in regard to the manner of election.

THE SECRETARY: The constitution provides that elections must be "by ballot deposited by members actually present."

MR. PHELPS: It is open to any one to vote against such a motion, but where there is no objection I think it is perfectly proper.

MR. MAYNARD: I should rather be inclined to object to this wholesale mode of voting. I think some of us would be beaten if the members had a chance to vote against us.

THE SECRETARY: The ballot is considered rather a sacred affair and the general procedure is that every one should be entitled to make an objection. If the matter is open for everybody to object, each has an opportunity to object, and if done proceed individually to ballot. Otherwise, a unanimous vote will permit this method to be carried out.

MR. MAYNARD: I agree with the proposition that the Secretary may cast the ballot of the society for any candidate, but I thoroughly favor that being done in the case of the President. If that motion is before the meeting I would second it.

MR. SHELBOURNE: I move that we proceed to the election. I think a motion in this form would obviate objection and meet the suggestions that have been made: I move Mr. President,—if no objection be made,—that the ballot for President be cast by a committee of one to be appo nted by the Chairman as and for all the persons present and entitled to vote.

The motion was seconded.

THE CHAIRMAN: Do you offer that as an amendment to Mr. Phelps's motion?

MR. SHELBOURNE: Mr. Phelps's motion, I believe, was with reference to all the nominations.

MR. PHELPS: I accepted Mr. Shelbourne's amendment a little while ago and confined it to the President.

MR. SHELBOURNE: Then I make it as an amendment to Mr. Phelps's motion. The amendment was carried and the Chair appointed Mr Phelps as the committee.

Mr Phelps, as such committee, cast the ballot of the Association for Mr. Frank L. Pope for President.

THE PRESIDENT: Gentlemen, I think it is proper for me to thank you very cordially for the honor which you have conferred upon me. It is one that I very highly appreciate, My only fear

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is that I am so unaccustomed to discharge the duties of an office of this kind, that I may fail in some particulars, but I will say that I will do the best I can for the Institute. (Applause)

We are now ready to proceed to the election of the remaining officers.

MR. WETZLER; I move that the Secretary cast one ballot for the remaining officers.

THE SECRETARY: I rise to make a personal explanation. In consideration of the fact that one of the same name and the same family has been elected President it may appear that there is rather an undue proportion of Popes on the list of officers, and I would suggest the substitution of some other name for Secretary in order that the criticism may not go forth that this is a family concern, as we have heard in some cases in regard to similar institutions.

MR. PHELPS; I think we will try to bear up against any insinuations of that kind that may be made. It would be unfortunate to have to deprive ourselves of the services of our Secretary for the past year on a ground of that kind, and we all know how carefully and efficiently the office of Secretary has been cared for by Mr Pope. I do not believe we want to swap horses now on any sentimental consideration.

MR. LOCKWOOD: No man is a more profound hater of papal aggression than myself. Under the present circumstances, however, I think I am willing to forswear protestantism. The only possible reason, apart from the sentimental one given by Mr. Ralph W. Pope for objecting to take the secretaryship, or to our conferring the secretaryship upon him, is that he may be desirous of the more remunerative position of Treasurer. I think to transpose the secretaryship and treasuryship, in this instance would be very hazardous, and that we had better adhere to our original nominations.

MR. WETZLER: As the Secretary is one of the officers to be balloted for, I move that the Chair appoint a member to cast the ballot. Motion carried. The Chair appointed Mr. Lockwood as the committee.

The SECRETARY: Mr. President, the committee report the following ballot elected as the voice of the meeting: Vice-Presidents, Norvin Green, Thomas D. Lockwood, George C. Maynard, Prof. W. A. Anthony; Managers, C. O. Mailloux, Sidney F. Shelbourne, Capt. O. E. Michaelis, Prof. C. F. Brackett; Secretary, Ralph W. Pope; Treasurer, Col. Rowland R. Hazard.

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MR. SHELBOURNE: Following out the suggestion of the results of the discussion with regard to the Past-Presidents or retiring Presidents, and understanding that the view is that it is merely complimentary, I think that it might be as well to disperse the doubts which I cast upon the question. Therefore I move that the additional designation of Past-President be attached to Dr. Norvin Green's name as Vice-President in the publications and transactions of this Society.

MR. LOCKWOOD: I am much gratified at the reconsideration of my friend's point, but at the same time, since he has brought the matter up it seems to me it is better to do this by a formal resolution now, and in hat resolution it would be well to convey also to Dr. Green the thanks of the Institute for his services durthe past two years, and I shall, with the aid of my friend Mr. Mailloux, prepare a preamble and a pair of resolutions which I trust will pass.

MR. JONES: I concur in Mr. Lockwood's view of the matter that it should come up on a formal resolution to express the thanks of the society, and when I make that statement, I think as a member of the Council it is also my place now to say, that Dr. Green has manifested a very kind interest in the welfare of this Institute. He has been at almost all of our Council meetings, has acted as the presiding officer, has given the benefit of his long experience and his far-sightedness and council in matters of great importance, and I know that the thanks which we are about to tender are doubly due to him. It probably was a little surprising to us all to know that he would, notwithstanding his many business cares come here so many times and manifest the interest that he has, so that in giving the thanks, it is not a mere formality at all, but I think one that should come with a good deal of heartiness from the members.

MR. SHELBOURNE: I believe my motion was not seconded; therefore it falls entirely and leaves the matter open to the suggestions of the gentleman who has just spoken.

THE PRESIDENT: While the resolution is being prepared, we will listen to the reading of the Secretary's report,

SECRETARY'S REPORT.

In compliance with the rules of the Institute, a brief report is hereby submitted, embracing a period of twelve months, which in addition to a statement of the condition of the society, con-

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tains certain observations which should be considered in connection with our future work.

According to the report at your first annual meeting, there were 279 names upon our roll, and as this number has diminished to 250, it is proper that the circumstances should be stated in order to account for this decrease.

It appears that in the informal proceedings which led to the foundation of the Institute, a large number of names were suggested by different persons present as being likely to assist in sustaining a scientific society of this character. These anticipations were not realized in a large number of cases, and no responses to communications addressed to them were received, either by my predecessor or myself, which would indicate a desire either to join, or otherwise promote the welfare of the Institute. In order to ascertain the disposition of these gentlemen, a circular was prepared with the approval of the Council, stating the circumstances under which their names were enrolled, and requesting a reply as to their intentions. A very large portion of those addressed failed to reply, a few declined, while a still smaller number availed themselves of the privilege of being continued as charter members, and expressed their best wishes for the success of the Institute.

The cash receipts of the year were $975.25, which are accounted for in the appended statement. It should be borne in mind that owing to the nature of the Institute, the payment of dues must be wholly voluntary. That is to say, in cases where individuals must look carefully to their personal expenses, their obligat ons to the Institute are a secondary consideration, and for this reason it is extremely important that the usefulness of the Institute be promoted, in order that membership may eventually be of such practical value as to attract the support of all who desire to elevate the standing of the profession. This is by no means a new problem in association finances. The field to which our labors are necessarily confined, is also occupied by other organizations, some of which are of a special character, and are doing excellent work.

The revision of the by-laws which had been found necessary, was undertaken by a committee appointed at your last annual meeting, which reported to a special meeting held on December 7th, 1885. The amendments were then thoroughly discussed, a few changes made, and formally adopted. The plan providing

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for the transfer of associate members to full membership has not been put into operation as yet, and I am therefore not prepared to give a report of its practical working.

The question of providing permanent quarters is not fully settled, but the matter is in good hands, and it appears probable that some of the plans mentioned will be adopted. Perhaps the most promising at present is the proposition to secure accommodations in a new building now being erected on 23d Street near Sixth Avenue. A temporary office was occupied on Liberty street for a few months, but not being essential to the welfare of the Institute, it was relinquished, and the Council has since availed itself of the courtesy of the American Society of Civil Engineers for accommodations. The hospitality extended to the Institute since its organization by this Society, has been most heartily appreciated by our officers and members, and while we have no reason to believe that these privileges will be curtailed in the future, efforts should be made to secure a permanent home at the earliest possible date, in order that our members may feel that their anticipations of a vigorous and growing organization are fully realized.

A communication from the Secretary of the National Telephone Exchange Association is submitted herewith inviting the cooperation of the Institute in securing the general adoption of the new English Standard Wire Gauge. Such action has already been taken by the National Electric Light Association, and the introduction of this gauge is I believe looked upon with favor by manufacturers and dealers. As the management of the three leading telegraph companies is represented in this body, there appears to be a sufficient reason for the consideration of the subject at this meeting.

THE NATIONAL TELEPHONE EXCHANGE ASSOCIATION.

SECRETARY'S OFFICE, No. 234 BROADWAY.

New York City, Oct. 1st, 1885.

Dear Sir:

I am instructed by vote of this Association to notify you that at its annual meeting held in Providence, R. I., last month the New English Standard Wire Gauge was adopted as the official gauge of the Association, and to request the co-operation of your Society, (in such manner as it may deem most effectual), in an effort to bring about its universal use as a standard wire gauge in the United States.

The advantages of a standard gauge are so obvious as to need no expla-

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nation, and it was believed by the Association that the above gauge, was upon the whole best suited for the purpose.

I would be glad to correspond with you further upon the subject.

Yours very truly,

C. H. BARNEY, Secretary,

To the Secretary of
THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS,
11 Wall Street. New York City.

The importance of the various electrical problems which are continually being brought to public no ice, points to the advisability of holding monthly meetings for the discussion of current topics. There are in New York and vicinity a sufficient number of members to make such meetings sucessful, especially if those who are capable, and have had ample electrical experience will perform their duty, in the preparation of suitable papers for presentation on such occasions. I can see no reason why such a gathering might not be held monthly in conjunction with the regular meetings of Council under existing arrangements. A suggestion of th s kind was made by my immediate predecessor, but not having been acted upon, I feel it my duty to state that I consider something of this kind absolutely essential to the future prosperity of the Institute, and earnestly recommend that the matter be taken up at this meeting. If possible I should be glad to see at least six members or associates now appointed, who should in turn present suitable papers for discussion on such occasions. At leas one meeting of this character might be held early in June and upon its success would depend the arrangements for future gatherings. I have already been promised a paper for this purpose, and it is very probable that gentlemen who could not comply with our request to submit papers at the present time will be glad to do so at a more convenient season. It also appears probable that if suitable arrangements were made for reporting the proceedings of these meetings, many important electrical papers would be brought before the Institute which are now presented to other societies, although perhaps entirely foreign to their special field. This is largely the result of a popular interest in electrical researches now existing, which we should avail ourselves of to stimulate the growth of the Institute.

With the inauguration of such a policy as I have outlined, your Secretary will feel far better satisfied with his work, and the existence of the Institute will gradually become more generally

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known, and properly appreciated by those for whose benefit it was founded.

Respectfully submitted,

RALPH W. POPE,
Secretary.

New York, May 18th, 1886.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

SECRETARY'S BALANCE SHEET.

FOR YEAR ENDING MAY 18, 1886.

THE SECRETARY IN ACCOUNT WITH THE A. I. OF E. E.

Dr.		*Cr.*	
To Initiation fees (13).	$ 65 00	By Cash to Treasurer.	$744 96
" Annual dues.	904 96	" Postage.	16 43
" Sales of Proceedings.	3 50	" Books and stationery.	2 45
" Cash from Secretary Martin	1 29	" Packing and moving.	5 50
" Stamp sold.	50	" Office rent (two months).	25 00
		" Desk and chairs bought.	30 00
		" Services Jan., Feb. & Mar.	150 00
		" Balance on hand.	91
	$975 25		$975 25

RALPH W. POPE,
Secretary.

E. & O. E.

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MR. PHELPS: I move that the report be received and placed on file.

MR. LOCKWOOD: With reference to the paragraph in which the Standard Wire gauge is spoken of, if I noticed correctly there was mention made that this gauge had already been endorsed by the National Electric Light Association. I think it should be amended slightly by adding the words "And the National Telephone Exchange Association." I mention this because that is the Association I believe which took the first official action in this country on that subject.

THE SECRETARY: I should perhaps have read this communication before taking my seat, which would have explained the point raised by Mr. Lockwood. This signifies that it has been adopted by the Telephone Exchange Association and will be annexed to the Report of the Secretary. I presume that will cover your point. [The Secretary here read the communication from Secretary Barney.]

The motion of Mr. Phelps that the Secretary's Report be received and placed on file was put and carried.

THE SECRETARY: I wish to offer a resolution if no other person is prepared to do so, to the effect that the American Institute of Electrical Engineers endorse the use of the new English Standard Wire Gauge and co-operate with the National Telephone Exchange Association and the National Electric Light Association in introducing it.

THE PRESIDENT: I would suggest that as the endorsement of the Wire Gauge is a matter of a good deal of practical and commercial importance, perhaps it would be well if some one would offer a resolution looking to the appointment of a committee to examine the matter with a good deal of care before coming to a final decision about it. It is not a matter that should be decided off-hand. It is a question that the manufacturers are very much interested in as well as the consumers, and it would be a good plan to get their views about it.

MR. PHELPS: I move that the resolution as offered by the Secretary be referred to a committee of three or five to be appointed by the Chair, just to get the thing started.

MR. LOCKWOOD: I suggest five, Mr. Phelps, that would represent all.

MR. PHELPS: Yes, five; a special committee of five.

The SECRETARY: I had no idea of actually proposing a reso-

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of that kind, but I would say, for the information of those gentlemen present who may not have attended the Telephone Exchange meeting and the Electric Light meeting, that in the first place the matter was very carefully gone over by the committee from the telephone association, and letters written to the various manufacturers of wire in this country, and that wire manufacturers were represented at Providence and took part in the proceedings, and at the subsequent endorsement of the gauge at Baltimore, although the examination into the subject was not as thorough as was the case in the Telephone Exchange Association, they understood how carefully it had been taken up, and consequently did not go into an exhaustive examination of the different gauges as they would have done if it had been an original plan. This matter was acted upon by the telephone convention last September, and endorsed by the National Electric Light Association at their meeting in February, and I fear that if it is referred to a committee and we undertake to go into it as they have done, it will merely bring us into the position of endorsing a thing that has actually gone into use, and so we will come in at the tail end, and say that it is all right after it has been practically adopted.

MR. PHELPS: I suppose it would be quite easy for such a committee to possess itself of the features of the investigations that have been made by the electric light people and the telephone people, by conference with them, to see just what the grounds are for the adoption of the new gauge. It would not be necessary for them to go over again all the work that was done by those associations; that might of itself be sufficient; but it does seem to me quite proper that some kind of examination should be made of the subject before we vote to approve the gauge.

The SECRETARY: I would say in reply to Mr. Phelps's suggestion that the information is very easily obtained. The published proceedings of the Telephone Association and the Electric Light Association, both of which I have, contain all the information necessary on that subject and the Telephone Exchange Association sends out this schedule of the sizes of the wire, and, I might add that the subject has also been very carefully gone over in *The Electrician and Electrical Engineer.* The matter has been tabulated and is in better shape to be acted on now than a year ago.

MR. MAYNARD: The question is whether it would not be well to know the result of the investigation made by the Telephone

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Exchange Association nearly a year ago. That is a thing that the committee might very properly ascertain. For that and other reasons I would favor the appointment of such a committee.

MR. PRESIDENT: The question is first on the amendment, that the matter be referred to a committee of five.

A MEMBER: When shall this committee report?

MR. PHELPS: At the next general meeting.

THE PRESIDENT: I think if the committee reports at the next general meeting it will be in season.

MR. MAILLOUX: Has anybody taken up that suggestion about the monthly meetings? It strikes me we ought not to let an important matter like that pass by. There is quite a sentiment in favor of that project in the body of the Institution, and I must say for my part that I favor it greatly. I believe in spreading the light all we can and keeping the Institute awake, and I do not think there is anything that could conduce more than monthly meetings to awakening a general interest in electrical matters, not only among the members but with the general electrical public. I know that abroad it is customary for societies to meet oftener than three or four times a year. You almost forget that you have been there after three months and forget acquaintances that you make. Then again the frequency of meeting should be made to excite interest in certain matters and perhaps to replenish the literature of electricity to a certain extent. People do not have time to write and elaborate their ideas and let others have the benefit of them, but if they have a chance to come together once a month or once in two months and exchange ideas, I have no doubt that the friction would have a tendency to benefit us all and keep us bright. In that way we would provoke discussion which is healthy for us all, and at the same time we are producing material that is subsequently published and is going to be beneficial. It will help to supply a long felt want in literature.

MR. PRESIDENT: I think we will postpone that a few moments until this other matter is disposed of.

MR. JONES: This is an amendment that is being put as I understand.

MR. PHELPS: No, it is a motion for a reference of the resolution which has been offered.

THE PRESIDENT: The resolution was to the effect that the

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Institute take some action in reference to the endorsement of the English Standard Wire Gauge, which has already been endorsed and recommended by the Electric Light and Telephone associations. Mr. Phelps's motion is that the matter should be referred to a committee of five, to report at the next meeting.

MR. JONES: Why I arose was to find out how far distant the next meeting would be, because to my certain knowledge the subject of wire gauges has been agitated for the last eight or ten years, and if I remember rightly you, Mr. President, wrote a very interesting article on it several years ago, and I think it has been bandied around from one side of the Atlantic to the other and finally the electrical people and the manufacturers in England took the bull by the horns and adopted a gauge. Now if we are to submit the matter to a committee and bring it up a year hence when the gauge is in universal use around us, I think we will be rather slow. At the same time, it may be that this society has not sufficiently informed itself of the merits of the new gauge to pass upon it very hastily. I am in a position where I don't know. I am neither a manufacturer nor do I use the gauge very much, but I have some general ideas about the gauge, particularly after reading your article about it. The idea was to simplify the gauge, not to have half a dozen, but to have one that was based on common sense, so that any one could use it. Now as we are going to have a meeting to-morrow, and this committee can report to-morrow, and we can put ourselves on record to-morrow, if we can bring the matter right up, we show ourselves sufficiently intelligent and have back-bone enough to get into the swim and say we endorse it, it would be much better than to put it off for a year and play the old fogy in regard to it.

The SECRETARY: I might add that the proceedings at the Electric Light Association were somewhat in accordance with the ideas of the gentleman who has just spoken. A committee was appointed to report at the next session. They held a meeting during the noon recess, looked over the proceedings and formulated a resolution to the effect that the association endorsed the action of the National Telphone Exchange Association and recommended to their associate members that the new gauge be printed in their catalogues, and where orders were accepted it was to be understood that if no gauge was mentioned the new standard gauge was the gauge. That was the way they did it. They re-

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ported at the next session; and if we can do that I think the action will be wise; but as it will be seen this letter is dated October 1st, 1885. It was presented to the Council, and the Council considered it a subject for the annual meeting and I so notified the Secretary of the Telephone Exchange Association. Now here is the annual meeting, and if we take up the matter and report it a year hence, why it will be a long time.

MR. PHELPS: When is your next meeting?

The SECRETARY: To-morrow.

MR. PHELPS: When is the next meeting after to-morrow?

The SECRETARY: A special meeting may be called by the Council at any time. There is no regular date fixed.

THE PRESIDENT: It is probable that no particular objection exists among consumers to the adoption of that or any other gauge so long as they are certain what it is. It seems to me that the objections, if there are any to it, will mainly be looked for among manufacturers. There are some physical difficulties in drawing wire to certain gauges. It is well known that it is less difficult, in drawing iron wire for example, to draw it to certain gauges, to a certain special range, I will call it, of sizes, than others. Although I have never studied the matter of the English gauge very carefully, I have been led to suppose that it was an attempt to simply remove the inequalities of the old Birmingham gauge and make it uniform in its sizes, a certain percentage of increase, and yet adhere quite closely to the old gauge which was found a practical one for the manufacturers. We have here with us this evening Mr. Wallace who probably is more familiar than any of us with the manufacturers' side of the question. Perhaps he will favor us with a few remarks upon it.

MR. WALLACE: I never saw the English gauge. I do not know what it is. I never saw the new gauge.

MR. SHELBOURNE: I inquired of one of the gentlemen present who I supposed had attended the annual convention of the telephone representators, whether the manufacturers of this country who draw the wire have got it in use or whether they have adopted it, and he could not inform me. As you have said, Mr. President, it is of considerable importance that we take hold of this matter, but is is suggested that the adoption by resolution of this gauge by the National Telephone Exchange Asssociation, by the Electric Light Association, and by the electrical societies of the country, would be the means of forcing this gauge upon the manufacturers.

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While that is very true, yet as you have remarked, there are some physical difficulties in the drawing of wire and it is a pretty hard way to get a gauge adopted if it has to be forced upon the people who are to make it and use it. I think it is wise that the committee that is appointed should consider this matter as presented in the letters and papers that are before the Secretary and report to-morrow. But there is a question about this gauge as to what it is called. We have heard it here to-night called the English Standard Gauge. We have also heard it called the New Standard Gauge. Now has it any precise title, and if so, what is it? I should like to hear the Secretary make some explanation on that point as to what it is called.

The SECRETARY: The circular of the National Telephone Exchange Association calls it "The Standard Wire Gauge adopted by the National Telephone Exchange Association, September 8th, 1885," and in parenthesis—this is the English title I presume, from the length of it—"New English Board of Trade Standard Wire Gauge, legalized March 1st, 1885."

MR. SHELBOURNE: If that is the case, I would suggest that this society leave off all those additional words and call it simply "The Standard Wire Gauge."

MR. LOCKWOOD: I have been through this discussion twice and it is very curious to note the similarity of t e arguments presented in all the Associations on the subject. I do not know but what in some of the Associations that I have heard talk about it some of the members were actuated by patriotism. I heard one gentleman in the Telephone Exchange meeting argue that because the Brown and Sharpe gauge was an American gauge we should stick to that whether it was best or not. I heard another gentleman say we ought to stick to the American gauge anyhow. It is not known in England by the long title the Secretary mentioned, but as "The Board of Trade Gauge." There were some dozen or eighteen gauges. Every manufacturer had a gauge which was right in his own eyes and the Board of Trade thought it was well to establish some standard, and even though it might not be the best it would certainly be better than the confusion which theretofore existed. As you suggest it is simply what was known as the old Birmingham gauge modified. The sizes are made to approximate more than they have done. One of the most pertinent arguments used at the Telephone Exchange meeting was that it was a step toward uniformity the

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world over, and as a step toward uniformity it was a wise step. It was said that the English certainly would not conform to our ideas and that therefore the best thing we could do would be to conform to theirs. As it has already been adopted by two organized electrical bodies of the country it seems to me it would be hardly worth while for us to go for a very extended period at least through the same investigation over again. What we do, or what we do not do, is of no great moment except to ourselves. What we do will either show that we fall into line with others, or will show that we are what are called in telephone centra offices "kickers." Those of us who order wire or use wire can get manufacturers to understand that if we order wire of such a gauge we mean the Standard gauge. If we wish to stick to Brown and Sharpe's gauge, we can say we want Brown and Sharpe's gauge, and yet after all is said or done, any user of wire who wants wirc of an exact size will continue to order by thousandths of an inch. I know I always do when I want it, specifying, of course, the resistance.

Mr. Mailloux: I think the last word said by Mr. Lockwood strikes the key-note of my own sentiments and I think those of every one who has to deal with electrical measurements. I think the grand millennium will come when we designate wire by thousandths of an inch as they do in Europe. This thing of knowing wire by a number and having it mean something like 1,175 mils is a very annoying thing. My memory is pretty good but it is not equal at all to compassing the sizes of wires in mils and the var ous figures that go with them. I think we should anticipate that to a certain extent. I should say before we adopt the Standard Wire Gauge, that we should see how nearly it comes to the great idea that Mr Lockwood and I both agree in of having the wire designated by mils—thousandths of an inch. I believe if a gauge was constructed on that principle, it is the kind of a gauge that we should look for. I do not care very much whether it is Brown and Sharpe's or British or Indian, provided it has those requirements.

Mr. Jones: With all deference to our brother member I do not think the subject of wire gauge is the one up for d scussion. We are merely speaking upon a motion for the appointment of a committee. Something has been said about nationality. I think nationality has nothing to do with it. We might as well talk about getting up another law instead of Ohm's law, because

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Ohm doe-n't live here. It would be as reasonable to object to Kepler's law because Kepler was not a citizen of the United States. Now I think we ought to pass upon this resolution to appoint a committee to consider the action of our sister societies and when the report is presented, if there are any members who do not understand the subject they can have all the discussion of it that is needed.

THE PRESIDENT: There is no reason perhaps why a committee should not be appointed to make some sort of report at the meeting to-morrow and either dispose of the matter to-morrow or continue it on a future day.

MR. JONES: We are not obliged at all to abide by what the Committee shall dictate. We can pass the matter over your veto even, if you would like to try it on.

The SECRETARY: I believe the only question about this is as to the time when the committee shall report.

MR. JONES: I move as an amendment that a committee be appointed as in the previous resolution and that it report to-morrow.

The motion was seconded.

THE PRESIDENT. As the motion now stands it is on the appointment of a committee of five by the Chair to consider the endorsement of that wire gauge and to report to the meeting to-morrow.

The motion was carried and the Chair appointed as the Committee, G. M. Phelps, Jr., C. O. Mailloux, T. D. Lockwood, F. W. Jones and R. W. Pope.

MR. PHELPS: I dislike to appear as in any way shirking anything in respect to this question, having offered the resolution; but my engagements are such that I fear I shall have difficulty in attending the meeting, except for a short time to-morrow, and therefore I am afraid I shall not be able to be of much use in the matter.

MR. JONES: I regret exceedingly that I have to get up and ask to be relieved. I would like to do everything I can for the Society, but the facts of the case are that my engagements for to-morrow and the next few days are such that it is impossible for me to do justice to the duties of this committee. I see some gentlemen here who are very conversant with the subject and very much interested in it and if you would do the kindness to the society and myself, particularly to the society, to relieve me, I would esteem it a great favor.

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THE PRESIDENT: Mr. Wallace, are your engagements such that you could not serve on the committee to-morrow?

MR. WALLACE: They certainly are. I will try to be here to-morrow but I cannot serve on that committee.

The SECRETARY: I will endeavor to provide all the information in the way of the Telephone Exchange and Electric Light Association reports, and also the table I spoke of, so that the work will be facilitated. It will be simply going over what has already been accomplished and printed.

MR. JONES: If it is necessary I will lend my copies of foreign journals, which contain the reports and discussions on the subject.

THE PRESIDENT: I think, Mr. Phelps, I will have to leave you on the committee and take the chance of your being able to help in the work. I think your suggestions will be of some value as you have had considerable to do with manufacturing in which wire is used. I suppose I will have to excuse you, Mr. Jones, as I know your engagements at present are very pressing. I will appoint Mr. Maynard of Washington instead of Mr. Jones. As the committee now stands, it is Messrs. Phelps, Mailloux, Lockwood, Maynard and Pope.

MR. LOCKWOOD: I am now prepared to offer this resolution, if the meeting is ready to receive it.

THE PRESIDENT: I believe we are ready to entertain it.

Mr. Lockwood then read the following resolution:

WHEREAS: Dr. Norvin Green, the first President of this Institute, has retired, after filling the office for two successive terms:

AND WHEREAS, he has during his tenure of office manifested the deepest interest in the success of the Institute, and has been unsparing in his efforts to promote its welfare and advancement:

RESOLVED: That the American Institute of Electrical Engineers is conscious of and fully appreciates the honor and dignity which Dr. Green has conferred upon it, and desires to recognize in a fitting way the earnestness and zeal which he has brought to the discharge of the duties of the office.

RESOLVED: That the thanks of the Institute be tendered to Dr. Green, and that as a mark of respect the title of "Past-President" be assigned to him, and that he be hereafter designated by that title in the records and proceedings of the Institute.

The motion was seconded by Mr. Phelps.

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CAPT. MICHAELIS: I do not want to appear in opposition to the motion. I believe it to be well deserved in every way. But I think at the same time, before we put it to a vote, we ought to consider it a little. I think it would be very well to put all our Presidents in that category. It is done in our American Society of Civil Engineers. I think the Institute has conferred whatever honor it could confer by electing the distinguished gentleman who has presided over it two years, and really I do not think we could strengthen the confidence and honor we have shown him by passing any special resolution. I do not know what more honor a society can do to a man than elect him two or three times as its head. I suggest that, with a view of avoiding possible invidious distinctions in the future. If we thank our first President we shall have to thank our other Presidents. Otherwise it will seem that the second, third and fourth Presidents have not rendered as meritorious services to the Society as the first President. I think they should always be known as Past-Presidents, for the simple reason that that is a mere statement of a fact.

MR. LOCKWOOD: The gentleman, I believe, was not present when we introduced this matter some time ago, but I might say here that he has stated precisely my intentions in offering this resolution. I think it is due to our Presidents that we should not only honor them by asking them to accept the office and perform its duties, but that after they have retired we should further honor them by conferring upon them a title without an office and to which there are no duties attached. I intend this moreover as a precedent, that not only Dr. Green should be hereafter termed Past President, but that the same title should be extended to every President of our Institute hereafter; and at the same time, as there was no such provision in the Constitution and By-Laws, I thought that it was eminently proper that this course should be taken, and it did not seem to me necessary that there should be any alteration. I trust that we shall pass these resolutions and that we shall hereafter be enabled to regard this as a precedent.

CAPT. MICHAELIS: According to our Constitution, I think the gentleman could reach the same object without any loss of time by simply proposing a Constitutional Amendment, and under that motion the amendment could be considered to-morrow. I believe that can be done under our Constitution.

THE SECRETARY: That was the decision last Fall.

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CAPT. MICHAELIS: So that if an amendment were offered tonight. that hereafter all Presidents of the Society shall be known officially as Past-Presidents we could act on it to-morrow.

MR. MAILLOUX: It strikes me, Mr. President, that by providing it in this way we would be having a sort of made-to-order title. It figures more in the light of an honor. It is not provided for and yet it is a precedent established, and it is a part of the unwritten law which all society has to deal with. If the by-laws provide for the appointment of a man as Past-President his being designated as such becomes a mere formality.

MR. JONES: There does seem to be this good feature about it, that if you are not compelled hereafter to follow the Constitution in putting Presidents on the list of Past-Presidents that you have a very good remedy against delinquent Presidents. If they do not perform their duties faithfully we can retire them in silence and not put them on the list. On the other hand by this method we will pay them the compliment of saying "Well done: we put you on the list,

THE PRESIDENT: It is with a great deal of pleasure that I put this resolution to vote. I know how busy Dr. Green has been, how many calls there have been on his time, and I only feared when we elected him as our first President that he would be unable to devote very much time to the interests of the Society. But I think I can truly say that there is no person connected with the Society who has exhibited more interest and who has done more for its advancement than Dr. Green. I think that every member of the Society will take the utmost pleasure in voting in favor of this resolution.

The resolution was carried unanimously.

MR. R. W. POPE: I know it is getting late and perhaps some of the members are tired, but I do not want to see the meeting slip away without taking some action on this monthly meeting business. I have no desire to see action taken on it merely as a matter of form. There are monthly meetings, and monthly meetings. The New York Electrical Society has monthly meetings, and with a larger membership than ours the meetings are not as well attended as they should be, and it is very often the case that meetings of this kind lack interest and for that lack of interest members do not come. If they came there would be interest and if there was interest they would come. This is a question that has been discussed I presume in every society that has ever been organized

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in New York City. But there is one thing about New York City that appears to operate against the success of evening meetings, and that is this gap which intervenes between office hours and eight o'clock. It is a good while to eat dinner in, and it is hardly sufficient time to go home and return in; I have talked to different members of the Institute about a plan by which we could meet at some down-town or up-town hotel, making arrangements for a monthly supper. If we stay we have to buy our supper anyhow. We could get the hotel to furnish a room for discussion, We could meet there at six o'clock and take supper or dinner, and the meeting could convene at half-past seven. We can all be there and get through the work in decent season. That would also give an opportunity for those who wish to dine at home in preference to remaining in the City, to go home and get back with the assurance that there will be a quorum when they return. I believe that by this means and by the appointment of one of our members to present a paper for discussion—not necessarily a very elaborate paper, but simply sufficient to bring up points for discussion, that we may have very interesting meetings. We stand very differently from some other societies. For instance, there is the Telephone Exchange and the National Electric Light Association—societies which are devoted to special branches of electrical work. They supply topics enough to bring half a dozen papers before a meeting on their particular branch; while we cover the whole field and consequently we have a vast range of subjects to choose from, and most of our members are competent to discuss many features of all of them. I merely present this outline as a matter for your consideration, for I believe it is essential to the welfare of the Institute that we should get together oftener than once a year, and become acquainted with each other and make our existence manifest. (Applause.)

MR. MAILLOUX: I have already spoken on this, but as nobody else seems inclined to get up and support it I will say something again. I scarcely need do more than simply reiterate what I said before, to the effect that I heartily endorse the project. I believe that it is the best thing that we could possibly do, and I also believe that it would be the means not only of keeping up the little fire that is now burning in the shrine, but also of making it brighter, and I hope that all the members will see this matter in the same light, at least those who are resident members. I suppose that a very large proportion of the members of the

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Institute are residents of New York, or the vicinity, and that a great many others who wh le not exactly residents live sufficiently near, so that they could make it convenient to come once a month or once in two months, so that all told I think we have enough to make a nucleus of quite an electrical gathering, one which would be a credit to the Association, while it would be the means of fostering knowledge, and as I said before of enriching the literature of the profession. At present, I may be forgiven for saying it, but nearly all the literature on electrical subjects of any importance comes to us from abroad. There they have societies which are well kept up, well organized and well maintained and all men of any note in electrical circles take a personal interest in the welfare of the organization. We have some of the best men coming forward with papers and giving lectures on the subject. The matter may not be absolutely new perhaps, but it is introduced in a new relation, which is just as good as if it were a new subject. Then in Europe we find that men are not so tied up to their own petty schemes. I will give as an instance a lecture given lately by Gisbert Kapp on Dynamo Electric Machines. Now Mr. Kapp is himself a maker of Dynamo Electric Machines. At the same time he undertook to give a review of the state of the art, and he did it very successfully and very ably, and in order to do that he had to go through the shops of other people, visit their establishments and study their work and study their facilities. Now that is something we could scarcely hope to see in this country. People are very jealous of each other's interests and it would be hard to persuade men to say anything about it themselves much less to let you look at what they are doing. Now I think that the American Institute of Electri al Engineers, by its monthly meetings, could do a great deal to wear off that spirit of suspicion which seems to be characteristic of nearly all electrical enterprises in this country, and in course of time we should find people more willing to come forward and drop their little mite into the sum total of human knowledge and in that way we would get to be a little better, a little franker and a little less conceited, which would be good for us all. So as you see there are more ways than one to look at the question and every way you look at it you can see it will be a benefit to each individual in particular and to the electrical community at large.

MR. JONES: It is a remarkable coincidence that the great

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Society of English electricians and telegraph engineers was first fostered by the civil engineers, who lent them their rooms and helped them in many ways. I believe that is about our position here to-night.

The idea that the Secretary has started of utilizing the early part of the afternoon or evening to gather somewhere—as many of our members reside across the ferries or some distance in the country is a good one. If they could meet at four or five o'clock then we could utilize our time. When we get through the strain of the day, to start in at eight or nine o'clock and get through at twelve and have to start for Elizabeth, New Jersey, perhaps at half past twelve, we do not like it, no matter how attractive the programme may be. Now this is a subject that I hoped would come up to-morrow I am sorry that I have to touch upon it at a time when you are all impatient to get away and I am the le as table to do it justice of any in the room. But nevertheless there is this fact, if we can associate ourselves with some eminent societies like the Civil Engineers, and can give something substantial for room and care and light, it would be better to come here and have an hour's meeting and then adjourn right acr ss the street and we can come back. As time passes on we can have our library and other things at hand, and we can have some electrical apparatus which you cannot cart back and forward to an hotel. Our Secretary's idea, in my mind, is splendid in the main, but a few little details could be arranged, I think, to better advantage, and it has been suggested that we postpone this subject until to-morrow morning.

THE PRESIDENT: The discussion is an informal one. There is no motion before the meeting. I would say that our Secretary seems to have given this matter some little attention. Perhaps he can inform us as to what formal action is necessary on the part of the Institute. As far as this matter of dining together and arranging about a room is concerned, that is a matter that the individual members can do as they please about. They have the privilege of meeting here if they want to, and if they prefer to meet somewhere else they can make their own arrangements. All we have to consider so far as I can see is what authorization from the main body of the Institute is necessary so as to give the proceedings an official character.

MR. JONES: I move that the subject of holding monthly meetings lie over on the table to be brought up any time to-morrow.

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The Secretary read the clause in the Constitution relating to meetings.

THE PRESIDENT: It seems to me from that, that all that would be necessary in any event would be for fifteen members to call upon the Secretary to have these meetings.

MR. MAILLOUX: I think it would perhaps be the best way to have as many of the members of the Association as are willing to do so form a kind of compact among themselves by which they agree to a programme of this description and if they present a resolution to the general body of the Institute, by which they would seek official recognition in so doing, it strikes me that would be the best way, If there is no motion before the house I would like to move that the question be brought up to-morrow. Is there going to be any regular business at to-morrow's meeting?

THE SECRETARY: It is not a regular business meeting but of course we can transact business.

THE PRESIDENT: This matter can be brought up by you or any one else at the meeting to-morrow.

MR. MAILLOUX: The matter should really not take much time if it is brought up in the shape I suggest now. I move that a committee of three be appointed by the Chair to consider the matter and bring in a suitable plan or project and report at the meeting to-morrow. The motion was carried and the Chair appointed on the committee Messrs. C. O. Mailloux, Ralph W. Pope and G. E. Phelps, Jr.

On motion of Mr. Phelps the meeting then adjourned.

GENERAL MEETING.

May 19th, 1886.

The meeting was called to order at 10:40 A. M., by the President of the Institute, Mr. Frank L. Pope.

THE PRESIDENT: The hour set for the meeting was ten o'clock, but as the attendance is rather limited in consequence of the bad weather, we have waited a little while. I think, however, as we have much to get through with to-day, we had better commence. The first paper on the programme is a paper by Mr. Sidney F. Shelbourne, which Mr. Ryan will read. The title is "Underground Electrical Systems."

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UNDERGROUND ELECTRICAL SYSTEMS.

BY SIDNEY F. SHELBOURNE.

I. Definitions and Principles.

There has been extended use, of late, of the word system as characterizing anything pertaining to construction for underground conductors. Thus he who has some form of box, or conduit material, or even a material in which to imbed underground wires is referred to as promoting "his system." Such misuse of terms is unscientific, loose, and confusing to the average comprehension. A *system* is "a whole plan or scheme consisting of many parts connected in such a manner as to create a chain of mutual dependencies and harmonious relations." An *electrical* system consists chiefly and primarily of a construction and arrangement of underground conductors, singly or in cables, connected with each other in lines of communication and so disposed *inter se*, or related to other material and space as to afford a harmonious and efficient electrical service for all uses. The conduits providing merely passages or ramifications of underground channels for the wires or cables, must always be considered a subordinate and minor part of the problem of underground electrical service.

The principles therefore which should control the preparation of this paper and the discussion upon it should be—(*a*), the exclusion of individual facts, materials and forms, except so far as they have a bearing upon the proper consideration and determination of systems of underground construction within the definition given;—(*b*) that prominent notice should be given to those elements which relate to the harmony of the different kinds of electric service when the conductors are assembled in conduits underground;—(*c*) the omission of details which must be essentially alike in all underground distribution, and on which the inventive mind has expended so much of sweating energy, as nipples, elbows, hand-holes, man-holes, separating bridges, insulating stuffing boxes, lead joints, and the division of lead covered cables, as well as the multifarious ways of connecting branch

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pipes and house wires. These minutiæ are better left to the obvious suggestions of individual promoters or the practiced skill of the finger and thumb electricians;—(*d*) the rejection from consideration, beyond a mere mention, of those pseudo-systems in which bare wires are buried in trains or beds of insulating material without the proper ceremony of even a pine box for conduit coffin. Such methods must be essentially vicious as to prevention of wire contacts, security of extraneous insulation, and the absence of consideration of dynamic induction as the chief element in the underground problem.

The French Government, 30 years ago, began its experiments in underground wires with this so called "solid system" and at periods until the present day we have heard of some new advocate of this "way" of burying the wires. So history repeats itself among the novices of science as in the recurring styles of hats and the bigness of bustles.

II. Conduits for Electrical Systems in Cities.

It must be understood that conduits, as here referred to, are confined to cities which admit of something like a *system* of underground conductors. A single channel under a country road or a suburban highway leading to the hay fields may be maintained with almost any material which presents a reasonable show of durability. In large cities like New York the conduit question requires more consideration because of circumstances more difficult and intricate. Here the question of material is important—(*a*), in the protection of the wires and cables from mechanical injury and the chemical action of fluids and gases permeating the soil; (*b*), in affording a means of harmony between the several classes of service, by aiding to shield the wires from the currents of induction; (*c*), in the promise of a permanent durability; (*d*), in the economy of money outlay and underground space.

A few facts will illustrate the first point. A company put down in this city, about eighteen months ago, two armored cables, each containing seven copper gutta-percha-covered conductors. For a portion of the distance these cables were drawn into 6-inch cast iron pipes, and have suffered no harm whatever. For the remainder of the way, the cables were laid at the bottom of an open trench in a layer of clean sand and then covered with blue-stone flagging of a thickness of 2 to 2½ inches, the trench filled with earth and repaved as before. On this portion

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of the line, at places, the gutta-percha insulation was softened and partially dissolved, under extraneous influences supposed to come from the pipes of water gas in the same street. The wires had become grounded through minute pin holes forced through the weakened insulation by the electric current. At one place on the same part of the line a pickman's stroke had split one of the blue-stone slabs and entering through the armor of the cables had denuded the wires of their insulation. Another company found recently in Wall-street that the insulation had failed in an electric light service, the superintendent of repairs giving as the cause, that a pick point had gone through the shell of a 2½-inch wrought iron pipe which had become partially corroded by some years of service. Such facts are probably recurring in this and other large cities, as to various underground pipes and constructions many times every month in which street excavations are permitted. If these conduits for electric conductors are to be made of plastic compounds and placed in the networks of other pipes underground in this city or other cities, where excavations and repairs are constantly going on, how long may such a conduit be supposed to escape the recklessness of an Irishman's brawn with a 9-pound pick above his shoulder. Public authorities have therefore wisely excluded earthenware and concrete pipes from general use under the pavements, because of this liability to fatal injury, among other dangers, by which the service they were intended to perform might become interrupted. As to the character of iron pipes, on the other hand, to be selected, it is a well known fact that the thickness of metal and the purity of the iron regulate the choice to be made. The thickness of the iron is made to increase in direct ratio to the diameter of the pipe, and the corrosion is found to be in the inverse ratio of its purity. Therefore a 2½ inch wrought iron pipe affords but a low limit of life under oxidation and an equally low resistance to injury by penetration as compared with a cast iron pipe six inches or more in diameter. It follows, therefore, that the cheaper the material the greater the durability. The telegraph companies who have put down wires in this country by their own methods have generally recognized these facts. An earthen, cement, or concrete pipe for a conduit will not allow of calking like ordinary iron gas pipes, so that the joints have to be formed solidly with cement or cognate materials, and the lengths are torn apart by expansion and contraction, and thus destroy them-

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selves unless buried at a depth so great as practically to secure an equable temperature, which again largely increases the cost of original excavation and renders required repairs difficult and expensive. Every one acquainted with the tables of the ratios of expansion of different materials can easily calculate the effects of thermal forces upon materials whose melting point is found at such low figures as 150° to 200° Fahrenheit. The co-efficient of expansion between zero and the melting point in materials of this class must of course be inordinately large. Of wood as a conduit material but little need be said. Such a conduit cannot, with ordinary care and expense be made water and gas tight, and even if this were done, a pick-axe in habitual excavation would soon disqualify that condition. Therefore such a conduit usually exists as a blind sewer or a nasty "hole through the ground" in which insulation can rot at discretion if not protected with lead, and if so protected then the lead in turn is eaten away in the rain water drainage impregnated with ammoniates and charged with carbonic acid derived from street droppings and vegetable decay in the soil.

Under the second point (b) all electricians understand the facts as to metals acting as screens to induction when giving a circuit or escape, in mutual connection, or with the earth and interposed between conductors or cables in use. A metal conduit thus shields the wires or cables within it from the dynamic induction of the conductors in use in a conduit alongside of it, by receiving itself the induced current and conveying it away to the earth at some available point or points in its length. If two or three separate metal pipes or conduits are placed side by side but not in general contact laterally, and each furnished with conductors or cables of distinctive service, a most beneficial anti-inductive agency would be realized from such a disposition of material. A misapprehension, however, has arisen founded it is believed on an error promulgated in an individual opinion or report made during the sittings of some committees in 1883 and 1884, under a self-constituted general committee on underground eleectrical inquiry. The opinion was given further extension in the first report of the Brooklyn underground wire commissioners, by misinformation, as though it had been made the deliberate conclusion of the committee on technique, which considered and ordered printed the individual report of 1884. A modification of the same opinion was urgently pressed upon the New York com-

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missioners in the Autumn of 1885 and during the early part of the winter just past. I refer to the statement that iron conduits have the effect *to retard* the currents in the conductors within them. The theory on which such an effect is claimed has not been stated nor can such a proposition be assumed or proven from the facts. The theory of static induction and consequent retardation when precisely stated and referred to practical examples can give no ground for such a notion of the effect of iron as a conduit material. The idea can only be referred, for probable truth, to theoretical considerations of the effects of dynamic reactions due to magnetic influences.

The third point (c) has already been touched upon in speaking of the character and purity of iron as determining its durability. There can be no dispute that hydraulic cements or bitumen and cognate hydro-carbons either singly or combined with other inert substances if considered as *materials* are more durable than the commoner metals; but the question is not of the durability of materials *as such* but of the permanent character of the *construction* as a useful form of conduit into which the materials enter.

The commonest and cheapest sort of cast iron six inch conduit tube the metal of which has a thickness of three-eighths to one-half inch if boiled in a preserving bath, as is now done, and avoiding a salt water soil, will doubtless give continuous service for 40 to 50 years. Materials less strong than iron are exposed to the liability of damaging and breaking strains from the sagging of suspended lengths during undermining or contiguous excavations; the continuous line of plastic lengths and solid though weaker joints in conduits of mastic concretes cannot resist the forces due to changes of temperature, since there is no mechanical provisions for expansion and contraction and the solidly adhering parts must give way. Such materials too are exposed to the softening and warping or collapsing influences of heat from the steam pipes, and the constant danger of ruin from the implements of excavation.

Of the strength of cement and glazed and unglazed earthen ware pipes many of us have had practical observation in the number of pieces which have been found chipped and broken merely in handling and transportation from the factories to the points of delivery. It has been found necessary therefore where such materials have been used for conduits for underground electrical conductors that they should be made so solidly and

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therefore so bulky of material that the openings or spaces left for the wires can bear but a small ratio to the total section of space required for the body of the structure. Hence we are met again with the question of expense for bulk of material and, more important, the essential room or trench which must be assigned to such structures under streets already variously lined with pipes of the several uses and at such random levels and make-shift positions as to render it quite impossible to lay out a line of regular construction. But such cements and other plastic compounds have been selected for electrical conduit materials for another reason.

It has been thought convenient, and until recently even necessary that conduits for the wires and cables should be made with a series of holes or passages through a body of material so as to allow of a division or separation of the cables into the different longitudinal channels or compartments thus formed, and that a metal could not be cast into such a form of conduit with money economy, nor properly and securely connected together in one contiuous length The reason for this leaning of favor is drawn from the settled experience that heavy conductors and cables in considerable lengths cannot be drawn into a single passage conduit in succession the one on the top of or alongside of the other because of the friction and the interference of movement between them. Hence a conduit body of plastic material has afforded the most convenient means of securing a considerable number of individual passages separated by walls or partitions in the material itself, so that each cable or assemblage of wires may have its hole or passage in exclusion. The English Post Office Department however has preferred to use separate small iron pipes instead of the pigeon hole structure, some of them of three inches of diameter into which 80 wires bunched together are drawn at one operation. In this country such plastic body conduits have been made to some extent, containing from three to seven channels for the wires of a diameter up to $2\frac{1}{2}$, 3 and 4 inches.

Such structures must be additionally very wasteful of space, besides the room required for solidity and strength of materials; for, if each passage can contain but a single cable or its equivalent of bunched wires, two-thirds of the wire space itself must probably remain unfilled by the cables. Had inventors sooner directed their energies to finding efficient means of drawing the cables and conductors successively as wanted for use, without injury, into

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compact position within the same tube or conduit channel of simple and cheap construction the question of how to find room for the wires under our streets would, ere this have ceased its bothering in the direction of multi-channeled concrete conduits and their pretentious promoters. But the interest in conduits of such a construction has been kept alive and stimulated by the plausible idea that each company now using overhead wires could have its own pigeon hole or compartment in a compulsory underground service. It has not yet perhaps occurred to all of us that if each company or party using wires is to have but a single compartment channel how many it would require to serve even present existing interests without a single thought for the future. But such a limitation would not answer the requirements of existing *companies* which use already a large percentage of the wires now overhead. If therefore on the other hand each or any company should be allowed to occupy the service channels *ad libitum*, how many vacant ones would the prominent existing companies be likely to leave for prospective rivals? The question of space, therefore, and control of such a conduit under our streets becomes one of the greatest importance, outside of the question of cost and durability to say nothing of the fact that conduit materials of an insulating character, have no agency, like a metal, to obviate the effects of dynamic induction.

It remains to notice the even grander suggestions of abortive genius in appropriating the sub-pavement spaces for the wires. The pravailing notions of a "sub-way"are without sense or practical calculation, and the word, with the notions attached to it, has unwisely been thrust into the legislation of this State as to underground wires. The general conception is that a "sub-way" must be a large viaduct or passage underground, like the Paris sewers or the Harlem Tunnel, and the idea for electrical conductors was evidently borrowed from the Paris sewers. Such constructions may be used if existing, but are out of the question as prospectively considered for electric uses. And yet would be inventors have loaded the rooms of the electrical service commissioners for this city and Brooklyn with drawings and models, the practical adoption of which would require a space of 10 to 100 square feet of vertical cross section, and a cost of $50,000 to $200,000 per mile. Even if such subways were practicable as to space and cost they would still fail to meet the requirements as to inductive harmony of the wires within them, while to allow the

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various companies to occupy them pell-mell with their different uses would be the culmination of a stupid folly. We may therefore dismiss a "sub-way" as thus conceived from the room of this paper.

The question of necessary first cost, for the same useful capacity, as between multi-channeled concrete, and a simple cast-iron pipe conduit, need not be attempted here, because, at best, hypothetical calculations for electrical service underground must be uncertain and of speculative value by reason of the varying conditions of the service proposed and the locality designated. We must therefore begin and stop at first elements. It is enough to say that cast iron pipe conduits as made in dry sand, and for the usual sizes, cost from one and a half to two cents per pound, while if the conduit be made of box castings with plates and shelves, which are required to be moulded in green or wet sand, the cost per pound will be 50 to 75 per cent greater. Concrete may be made of a weakness or strength, within its limit, depending upon the will or honesty of the contractor, whether of hydraulic cement or an asphalt and coal tar basis, and the cost will vary in proportion.

III. Specific Inductive Capacity—Induction—Insulation.

No one has yet been able to tell us why it is that induction takes place through one kind of insulating material more readily than through another, any more than why, in the nature of things, copper should be a better conductor than lead. The essence and mode of electricity itself must perhaps be brought to demonstration before these questions can be answered. But it is clearly an experimental fact that inductive capacity of insulating materials has no immediate relation to quality as insulators. The table of substances experimented with shows a considerable irregularity and a remarkable variation in inductive capacity, ranging from 1.77 to 5 in comparison with the standard unit of dry air. The writer is led to speak of inductive capacities of insulations by the confusion which has arisen from the lack of proper distinctions in telephone service, between what is apparent as due to the conditions of static and dynamic induction respectively, and also because of the claims which have been made as to the merits of some of the underground cables.

It has come to be a tenet well received among electricians that "the better the insulation the greater the induction." This is

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particularly true of dynamic induction, as is well observed on telephone air lines in the difference between a wet day and clear, dry weather; but it is not altogether true as to static induction as one of the practical difficulties of electrical communication, for we have the example of a rubber insulation giving a much greater static induction than a high class of gutta-percha, and it has been the boast of some of the English manufacturers that they have increased the insulating quality of their gutta-percha and at the same time reduce its specific inductive capacity some 20 per cent. In this country a claim has been made that by reason of the low specific inductive capacity of an insulation used, an anti-induction cable is secured, (evidently referring to dynamic induction,) while the insulation itself is claimed to be very high up in the megohms. Let us examine the possibilities of this claim. In the first place, dry air is the standard to which all insulations are referred as well as all inductive capacities of their materials. We have seen, secondly, that dry air insulation is more favorable to dynamic inductive effects than damp air, and as the lowest known inductive capacity of solid insulation is 1.77, as compared with the unit of air, the claim is a fallacy as to dynamic induction, but as to retardation, the result of static induction, the claim is true, because long since proven by the insulations used on the conductor cores of the ocean cables. It follows, therefore, that the claim is mixed with both merit and demerit. It should be founded upon a low specific inductive capacity and a *low*, but permanent quality of insulation. But even when predicated of static induction the claim is of less importance than other considerations in the case of subterranean cables consisting of many conductors together in the same general body of insulation. For example, if we have given a lead-covered cable composed of many small telephone wires in a body of insulation comprising their individual insulations and a general inclusive insulation whose diameter inside the lead may be an inch and a quarter, then, if a wire be selected for use at or near the centre of the cable and the others are not connected through instruments or directly with the earth, the conditions would be most favorable for a low static induction in the use of that one wire. If some or all of the other wires were connected with the earth the static induction would be increased in inverse ratio of the distance of the earth wires from the wire in use. If, instead of using the wires in such a cable as ground circuits they should be formed by pairs or quadruples into a cable of

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strands and used as metallic circuits, the best invariable conditions of a favorably low static induction would be secured, aided, of course, by the low inductive capacity of the material of insulation and varied also inversely by the insulative quality or the amount of leakage indicated. But in cases of static induction, leakage and induction tend to the same disadvantage, because the greater the leakage the longer the time of charge, although the leakage to its extent, counterworks the static induction. Premising the conditions to be single insulated conductors in wet earth or water, the elements which determine static induction are four: the surface area of the conductor; the thickness of the insulation, or its exterior surface, which will vary in direct ratio in round forms; the insulation quality; and, lastly, the specific inductive capacity of the material of insulation.

While it is true that the specific inductive capacities of insulating materials have been experimentally determined alone in their relation to static induction, yet, if we may believe or assume that both static and dynamic induction are referred to the same source or origin in the nature of electricity and stand for the modes of its energies, there is no reason to deny, so far as any promulgated experiments are known, that insulating materials may not have a like capacity with relation to dynamic induction. At least we shall here assume the fact to lie in the majority of probabilities in favor of such a capacity. So that, as to dynamic induction between any two conductors insulated from each other, the elements are: the quantity and intensity of the current; the distance between the lines of average of parallelism of the conductors; the character of the insulation or the leakage *between the conductors;* and lastly the specific inductive capacity of the insulation.

Dynamic induction acts by laws and under conditions as invariable as the forces of gravity and yet we find repeated again and again the experiment of simple parallel wires bunched in cables and used for short distances with fair success, when at once the happy self-styled inventor rushes into print with a certificate from a climbing electrician, and the word "anti-induction" in heavy block capitals.

Of insulations but little need be said, because the subject is hackneyed of words. The whole list is good—better—best, and every new man can give us the best, because, he says, God has made him the Mahomet of a new revelation. Gutta-percha and caoutchouc

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are well known and long tried. For salt water, gutta-percha is unexcelled, but for underground lines it becomes hard and cracks and is subject to peculiar influences of decay, often of local and undetermined character. Para rubber of low vulcanization is better for underground work, but costliness excludes it from general use. The great cost of these chief insulators early led investigators to seek for substitutes. The lists of hydrocarbons were explored. Prepared bitumen and coal tar were brought into use and combined with other substances, mineral and vegetable. It is a fact as old as the cyclopædias of our day, that vegetable oils heated with a proper percentage of flowers of sulphur added at a limit of temperature, will become tough and elastic, yielding an artificial caoutchouc. This property has been made the basis of many of the patents for new insulations, the claims of which relate mostly to manipulation and proportion of constituents. The longest known "ites" are of this class. Other insulations are derived principally from the material of worn-out rubber boots and the scraps and bits from the rubber factories. Some of these also add to the "ites" a necessary toughness or elasticity. The fundamental process is simply the maceration and softening of the old material in oil of turpentine, and the separation and use of the available portions. Those insulations which have to be put on the wires by means of press and dies must always be considerably expensive for materials and labor. Then, too, some of these insulations are easily affected by ordinary weather temperatures. Copper wires have been known to drop by gravity through their gutta percha insulations when lying supported, simply by the softening of the insulation in summer heat. The steam pipes in this city would bring havoc to such insulations of homogeneity, softening at a low temperature. This fact has become so well understood by the experience of one of the companies that an injunction is in force, at this writing, restraining the Steam Company from placing its pipes in the vicinity of wires previously laid.

An insulation for underground wires should secure the copper conductor invariably in a central line within it. It should contain no elements of chemical change or deterioration as an insulator. It should be cheap, easily applied, and not liable to injury in manipulation after it has been applied. A low insulation permanently maintainable is the best for short lines and local service. Such an insulation with large sized copper conductors was among

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the first propositions laid down by the writer some years ago. In the Autumn of 1884, an experimental piece of underground telephone plant was put down in this city, in which the immediate insulation of the wires was cotton fibre in loose braidings on the wires which were then steeped in a hot bath of linseed oil. The insulation at first was very low, the best of it not giving per mile more than one-third of a megohm. In January, 1886, further tests showed that the insulation had so improved that the lowest gave a mileage resistance of one megohm, while the highest ran up to *seven* megohms. The writer ascribes this improvement to the slow oxidation of the oil into a thick gum of higher insulating quality than the fresh oil. It is maintained, as the result of experience with insulating materials, that a permanent insulation of from 50 to 200 megohms per mile is easily and very cheaply available for underground lines in which cotton fibre forms the basis of attachment or the vehicle of the prepared insulation.

IV. Protection for the Insulation.

As long as the expensive and homogeneous insulations were almost exclusively used, their capability to exclude moisture for a long time rendered further permanent protection scarcely desirable. But the multitude of wires and cables brought into being by the progress of the telephone, called for the economy of cheaper insulations which required a durable extraneous protection. Even for ærial lines a light lead pipe, containing a large number of small wires, has come into extensive use. The tendency to adopt a lead jacket or covering for underground cables in the last five years has become almost universal, and only the older telegraph companies still adhere to homogeneous insulations and gummed taping for outer wrapping. The lead method thus far has been somewhat primitive and imperfect. At Philadelphia, in 1884, lead protected wires were exhibited, in which the thickness of the lead on one side was twice as great as on the other, and many productions of lead covering of the roughest exterior have been sold to telephone companies, with the insulation loose within the lead, and the shape of the finished cable neither round nor of any other ascertainable contour. Lead pipe coverings and lead press jackets put on thus loosely and unevenly are radically bad, since they do not exclude the air from the insulation, nor give assurance, therefore, against decay and deterioration. The perfection of the lead process is to be able to force the lead, while cold, close down upon

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the surface of the insulation and, without injury, sealing up as it were, the insulation within a uniform thickness of metal having a round and smooth exterior surface in the finished cable. Such a lead covered cable, with a well considered insulation, and barring accident and mechanical injury, would afford a guarantee of permanency for indefinite years of the future.

V. New Dangers, or Water Gas and "What is It"?

Reference has already been made to the solubility of gutta-percha insulation in cables exposed to the soil without conduit protection underground in this city, by some agency supposed to come from water gas. The first suggestion was that it was the naptha used in the manufacture of that gas. This must be an error, because the naptha does not exist in the gas in the form of *vapor*, but is decomposed in the manufacture and yields two distinct *gases; i. e.*, light carburetted hydrogen, $C\,H_4$, and olefiant gas, $C_4\,H_4$. From the best judgment which can be formed without actual experiment it is probable that one or both of these gases are capable of attacking the hydro-carbon insulations, since these gases themselves are cognate members of the hydro-carbon family.

But a more surprising apparent observation comes from the Brooklyn Commissioners for underground wires, in which it is alleged that water gas or some constituent of it will act upon metallic lead so as to convert it into the carbonate or white lead of commerce. The writer has taken pains to investigate this question both on his own effort and through an analytical chemist. The theory of such action necessarily requires the exhibition of carbonic acid gas. Water gas contains the merest trace of it, since, as a deleterious constituent, it is carefully eliminated in the manufacture. But to supply this for the lead attack it has been surmised that the monoxide, $C\,O$, of which water gas contains from 25 to 30 per cent of its volume, presumably undergoes after its escape from the pipes into the soil an additional oxydization and becomes the dioxide $C\,O_2$, or carbonic acid. This is an extreme improbability since it is known that the general action of soils is de-oxydizing rather than aiding to a higher oxidation, except under peculiar conditions in the presence in the soil of vegetable charcoal, and even in such cases the action is limited and insignificant. But why go in search for an explanation to the water gas pipes, when a known one is of ready suggestion. The Brook-

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lyn conduit was a wooden box, admitting fresh water surface drainage impregnated with carbonic acid and ammoniates from the street manure and the decaying vegetable matters in the soil. Cold rain water will absorb a volume of carbonic acid equal to its own, while the monoxide from the water gas is scarcely absorbable at all. We have therefore the conditions of a ready action upon lead as will appear from the memorandum of Mr. Lucius Pitkin, analytical chemist, here following.

MEMORANDA ON CORROSION OF LEAD PIPES IN GROUND FROM LEAKAGE OF WATER GAS INTO SOIL FROM GAS PIPES.

1. There are present in the soil under the streets of a city like Brooklyn, where from traffic a considerable amount of organic matter is present on the surface, the organic acids resulting from their decomposition. I mention:

(*a.*) Crenic acid.....	Watt's Dict.,	Vol.	II., p. 103.
	do.	do.	VII., p. 393.
(*b.*) Apocrenic acid..	do.	do.	II., p. 103.
(*c.*) Humic acid....	do.	do.	VIII., p. 1043.

Experiments by Simon point to the conclusion that humic acid renders ordinary calcium phosphate soluble, showing thus considerable solvent action.

2. Parke's Text Book, Am. Ed., p. 16, states that the action of water on lead is great in those containing organic matter, nitrates, and, according to several observers, chlorides. These would occur in the soil water of Brooklyn from soakage and decomposition from surface.

3. *Medlock* attributes the greatest influence to ammonium nitrite formed from organic matter. Lead nitrate is rapidly formed and carbonate is then produced, the nitrous acid being set free to act upon another portion of lead.

4. The amount of carbonic acid contained in the air of the soil normally is high where the conditions are as in a city street.

"In some rich soils the amount contained in the air present in their interstices is 250 times greater than the ordinary atmosphere ratio."—*Bassingault.*

"The rain, already charged with carbonic acid in its passage through the lower regions of the atmosphere, becomes more largely impregnated with this gas when it sinks beneath the surface."—Wilson's Hygiene, page 141.

In view of all the above causes present in the case, the amount

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of action due to any ordinary leakage from gas pipes containing the small percentage they do of carbonic acid, is practically nothing under the conditions stated by you.

LUCIUS PITKIN, PH. B.,
Chemist.

To S. F. SHELBOURNE, Pres't.

Prof. Silliman says: "Lead is acted upon by distilled water and by rain water. Water, by reason of its affinity for the oxide of lead, acts like an acid upon metallic lead. A bright slip of pure lead is tarnished almost immediately in pure water, and after a short time becomes covered with a pellicle of carbonate of lead."

Whatever may be the true explanation of the formation of the lead carbonate in the Brooklyn case just stated, the argument from the facts would be that those cables should have been placed in iron or other conduits, excluding both water drainage and gas, so that no corrosion of lead could have been possible.

VI. ELECTRICAL HARMONY OF USES.

It follows from what has been said of parallel wires and dynamic induction that to harmonize the use of the heaviest currents for light and power, with the feeblest for the telephone, something further must be provided than underground possibilities of distance between the conductors. It is stated that with the present ærial spaces between them it is impracticable to work the telephone lines on lower Broadway after nightfall because of induction from the arc light conductors on the opposite side of the street.

There are two possible ways to harmonize the uses of the wires. One by induction screens forming circuits with themselves, or with the earth; and secondly, by a scientific arrangement of the conductors themselves in relation to each other and with reference to the different uses. These two methods may be combined with each other, and when so combined the best possible conditions of harmonious use will be realized. Metal screens may be so placed and associated as to protect individual conductors in relation to each other, or classes of conductors as between the classes. These provisions may both exist together, i. e., both screens for the individual wires and for the groups or classes may be combined in the same examples of construction. This may be

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done with the individual wires in ground circuit, or, better still, with metallic circuits for the trunk lines between the exchanges, operated in connection with ground circuits for local wires of short distances and deviating direction.

With reference to arrangement of conductors, here also two possible methods are admitted, though one of them rather belongs to the theoretical than the practical phases of the question. Theoretically, and with sufficient space at command, electric light circuits may be placed with their limbs parallel and separated from each other in the same general line of sub-way or conduit space and the telephone wires brought alternately for equal lengths within contiguous relation with the one limb and the other by crossing at regular intervals. Practically, with many wires of different uses, such an arrangement could not be economically available nor in any case can it afford a protection against dynamic induction between wires of the same class, which are usually in the closest assemblage in cables underground.

The single practical arrangement therefore of the wires is to arrange those of each class anti-inductively, when necessary, between themselves and then in the same manner as between the classes. This can be done with rigid economy of space by laying up the smaller wires in proper strands within cables, instead of parallel singularity, and by joining the limbs of the electric light circuits in fixed unity of relation with each other where ground circuits are used for the telephone wires, but where the latter are formed in metallic circuits, within cable strands, the electric light circuits may be used in straight-away or single limb lines presented to the telephone conductors, without inductive disturbance. It is reported that in exhibiting the Chicago underground wires at the beginning of the past winter a considerable stretch of telephone wire underground in connection with some miles overhead, and in ground circuit, was used successfully though passing underground for some two or three blocks parallel with and near to the underground electric light conductors then in service. It was not proclaimed, of course, that the two limbs of the electric light circuit were in the same conduit and probably exactly equi-distant from the telephone wire, for such a declaration would have been fatal to the object of the exhibition.

The whole problem of harmony of uses is of easy solution upon scientific principles well understood among electricians who have given attention to the subject, so as to make *a system*, as such, not only possible, but economically practicable.

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VII. What We Have Come To.

The subject assigned to the writer by the Council and formulated in the caption of this paper is "Underground *Electrical* Systems." Can it be possible that we have been writing thus far without anything existing to write about? It seems to be so. If we look about the world for "Undergound *Electrical* Systems," we can find none. Somebody has referred to the underground conduit and cable work in Chicago as an "embryo system." It can hardly be classed so far in advance as that; it must be *conceptive.* And yet there is a quarrel between Chicago and Boston as to which stands first in underground honors. Before this dispute can be settled, Brooklyn expects to canter forward as a dark horse and reach the reward offered, of a clean looking city. But Brooklyn has yet to nail up her boxes for four-fifths of the work promised, to say nothing of the cables to line them. Even in that inchoate achievement, under legal provision and supervision, there are no assurances, as yet, of any attempt to secure *a system.* The heavier and inductively hurtful uses of electricity which present the seemingly difficult elements of the problem have, thus far, been left in abeyance.

But while this paper has not been able to treat of the happy success and details of existing systems, it is to be hoped that what has been written will open more clearly to the thought of electricians and other students of science, and to legislative and popular comprehension the elements and the conditions, both legal and practical, which should be brought into action in *creating* "underground electrical systems" for the future. As has already been noted, an electrical "system" must combine the *electrical uses* so as to secure mutual harmony in the general service. The various companies have heretofore, in all the cities of the country, whether by law or self-will, put underground each its own wires in its own way, and for its own special advantage alone. Could any one expect harmony of uses in such a state of things, or could *a system* be hoped to exist under such conditions of diverse individual purpose and action.

VIII. Conclusion.

A summary of the facts and considerations advanced will lead to the conviction that no underground electrical systems will be realized in this country until the several cities in which the overhead net works have become a nuisance awake to a conception of

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their public rights and duties as to underground wires. It is very clear that the individual companies, pursuing their own interests, especially where valuable patents and monopolies are still for a few years at their aid, will seek strenuously to extend and establish those patents and monopolies by occupying the spaces under the streets with their own wires in their own way, so that both the wires and the spaces shall enlarge and perpetuate their own advantages to the exclusion of possible competition. If this were allowed there would soon come a war of contentions. The telephone companies must and would seek to exclude the deadly electric light conductors from the spaces near their weaker lines as has already been done with the conductors overhead. There would be a struggle and contention for spaces, a perpetual digging side by side and in succession in the same streets, until the annoyance would raise a public clamor to sweep away the nuisances as with a whirlwind. To build a conduit merely for the use in common of existing companies would be equally and even more disastrous in the end, since the companies themselves could not agree about their diverse wires with each other; nor would it be possible to assign by legal authority a division of privileges and spaces between them. The result would be that the strongest would win the fight, control the conduits, laugh at expectant rivals, and dismiss from their calculations all fear of competition.

There is only one practical solution for this underground wire problem. The cities themselves in this country, as the governments in Europe, must own and control *the whole system*—both conduits and cables—constructed and arranged in harmony of service beneath the pavements; or, if such a course is not within their municipal powers or consistent with public policy, then the city authorities, where wires are to go underground, must control, absolutely and perpetually, the single company allowed to occupy the streets, so as to fix at all times in the public interest and fairness to all users, the rental for the wires; and more important still, to see that equal opportunities are secured for new companies who have the means and the will to establish a fair competition in the public interest and for the general welfare.

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THE PRESIDENT: We have listened with a great deal of pleasure, and I hope not without some profit, to the very interesting paper of Mr. Shelbourne, who, as we can all see, has given very careful attention to this subject; a subject which I think you will all agree with me in saying is by all odds the most intricate and difficult one which the electrical engineering profession has to deal with at the present time. It affords abundant opportunity for discussion and probably will continue to do so for some years to come. I see Mr. Lockwood among the members present this morning; he has paid a good deal of attention to this question in the course of his every-day duties, and I hope he may be able to favor us with a few remarks on the subject.

MR. LOCKWOOD: It is with much disappointment that I note the slenderness of the representation here to-day. I am quite sure that this room might have been full of members who could have listened with profit to such a paper. I am glad to say I have been instructed and interested, and perhaps I ought to say that some portions of the paper have even amused me. I say that in all deference to the ability of the author.

The paper of Mr. Shelbourne seems to refer more particularly to systems of wires which comprise all or a great number of the different utilizations of electricity. I am entirely in accord with his prefaratory remarks regarding the use, sometimes totally unauthorized use, of the word system. The word has been applied to a great number of inventions and plans and schemes which are characterized more by lack of system than by any other one feature. Perhaps the company with which I am officially connected has done as much as any one concern in North America upon the subject of underground conductors. We have not believed that the overhead wires are so much of a nuisance as people who have nothing else to do but to think of underground wires, believe. We think that wagons, carriages, and carts, and sometimes buildings, though useful are at the same time not ornamental, but we are very willing to tolerate them for a few years longer upon our streets because of their uses, and believe that the same considerations should guide us as we listen to the cry which has been made about the uses of overhead conductors and wires, about their unsightliness and about the trouble which they bring on roof owners and everything that is said against them. In talking about these things however, we sometimes lose sight of their utility, and of the fact that

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if they were not used and not useful they would not be tolerated for a moment; but we have also recognized that sooner or later the majority at least of the wires must be put out of sight, and we believe that ultimately the increased expense of burying the wires will be offset by the decreased expense of maintenance and by the comparative ease with which future discoveries will enable us to work them. In view of this, we obtained rights in Boston and ran a pair of conduits in two directions from the main central telephone office, at the corner of Pearl and Franklin, towards State, which is the Wall street of Boston, and another up Franklin street towards Washington street, and there are between 700 and 900 miles of wire now laid and operated as telephone conductors. The method we adopted was what is sometimes known as the Mackintosh system. It consists in establishing vaults or chambers underneath the surface of the earth, at street corners, and digging trenches from chamber to chamber and depositing iron tubes in those trenches, surrounding the tubes with concrete or other cement, and then drawing cables through the iron tubes. The size of a tube is three to four inches with gas thread joints. We lay the tubes first between each two chambers, and draw the cables in, and to be perfectly fair we adopted for trial all the good cables we could find, and we found that they all worked fairly well mechanically. As for insulation we found the chief trouble we had was at the joints in the chambers, and at the ends where the wires were separated. We brought the tubes right into the basement, and then carried them up by lead-covered cables to the operating room. We ran the same grade of cables up to the top of the building where we finally distributed the lines to the several points of destination. As I understand it, by the law which is at present in force in New York, *that* is prohibited, and the wires must stay underground from the point they start from, to the point they reach; and, after that, they must stay underground, because no wires are allowed to be above the surface of the earth, even in buildings. But we found they worked fairly well. Even in a half-mile line, however, of telephone wires underground, retardation, due, of course, to static induction is perceptible, though not to the subscriber. But when a subscriber comes to add on to the length of his line, say from the central part of Boston to Jamaica Plain, retardation is plainly perceptible indeed. The subscriber does not know what to lay it to, and we do not usually tell him. He generally lays it to a bad battery or to

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the transmitter, and he usually makes it the basis for an application for a rebate. There is another thing quite noticeable in this relation which I have seen referred to in the British text books with respect to the automatic system in vogue in England. Messages originating at the end of the underground section can be carried to the other end of the overhead line and will come up and be reproduced in articulate speech much easier and clearer than messages going the other way. Messages, for example, originating at State street will come out fairly clear at Jamaica Plain, but speech transmitted from Jamaica Plain comes out in a very muffled sluggish way in Boston. This is entirely as it should be. Although I am not particularly impressed with the result as being favorable to business I am glad to think that it corroborates theory, because when the electricity generated by the induction coil of the transmitter starts out from the underground end it is fresh. It has the hardest part of its work to do while it is fresh and consequently it does it well, and the overhead part of the line is comparatively easy on account of the distance from the earth and is traveled over with facility, whereas coming the other way the telephone current is slender. A little leaks off at every point of support, and when it arrives at the point where the hard work commences there is not much left to it. The consequence is that it nearly all is dissipated upon the surface of the conductor. In Pittsburgh, Mr. Shelbourne's paper to the contrary, notwithstanding, I think there is more telephone wire underground than in any city of the Union. There, wooden troughing is adopted, in which lead covered cables are laid. They are not more than a mile long, and a majority of them not more than half a mile. They are brought out on poles at the end of the underground stretches and distributed, and for some reason, retardation is not so perceptible in Pittsburg as in Boston. In Washington we have to put wires underground on account of the æsthetic tastes of Capt. Green. Capt. Green set out to find out what wires might be laid underground, and what wires not, and he interviewed certain electrical engineers, some of whom are in this room now, and in his investigations he found out that the British government had its wires in London in tubes under the sidewalks, and he did not care to investigate further, and consequently, from that evidence, jumped at the conclusion that as some wires are under ground for a certain length, all wires might be put under ground indefinitely, and he

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made his report accordingly; and it is now stated by legislative bodies especially, that there are no wires overhead in Washington. Any person who has been in Washington lately, would find it hard to believe that there are any wires underground, so many are overhead; likewise in Chicago.

I noticed that, in Mr. Shelbourne's paper, the statement is made that all electricians understand that metal envelopes connected to earth act as screens for induction. Now, for the last five years, I have disclaimed the title of electrician, because I do not like to be in the majority. There are a great many electricians, and while they may all understand that metal envelopes connected to earth act as screens, I, not being an electrician, do not altogether agree to that statement. It is true, if you have two conductors, and place a metal screen between them, and charge one of them statically, that metal, especially when connected to earth, does act as a screen. It is not actually true that metal envelopes around metal wires connected to earth, act entirely as screens. There is no doubt that the induced current between the two wires is checked, to some extent, by any metallic covering, because the way it acts is to develope a current in the intermediate conductor, *i. e.* the metallic envelope itself and by connecting to earth we extend that wire indefinitely; that is, you make the earth a part of the screen, and by so doing you disseminate the induced current over a large amount of surface, and thus the effect is carried away to a certain extent from the adjacent conductors. Incidentally, I may mention that the United States patent which covers that point, expired yesterday; so we may now cover all our wires with metallic screens, if we wish to, indefinitely.

MR. SHELBOURNE: I referred entirely in my paper to dynamic induction. Such metal screens connected to earth increase static induction of course.

MR. LOCKWOOD: There was another point mentioned, based upon the statement in the report of the Brooklyn underground commission, which I thought myself was somewhat unaccountable —that the use of iron was detrimental to the flow of electricity in conductors—the use of iron in an envelope or screen. It has been found, and I think not very long ago, that different metals used as conducting envelopes had different results, and I have found, and my associates have found that while the results attained by the use of aluminum, bismuth, copper, brass, lead, tin, and many other substances, are all alike; and if you do not connect

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them to earth there is no great effect, yet if you inclose the insulated wires in iron, particularly very soft iron, there is a very pronounced effect in the diminution of dynamic induced currents from one wire to the other. The reason I think is that the force of the induced currents by virtue of the doctrine of the conservation of energy is transformed in that soft iron covering into a certain amount of magnetism and is thus prevented from exercising itself adversely in the formation of an induced current between wire and wire.

There was a further statement made as to the relative effect of induction between telephone wires in wet and dry weather. It is an undoubted fact that telephone wires, especially long ones, have worked much better in wet weather than in dry It is also a fact that telegraph wires, with bad joints in them, work better in wet weather than they do in dry, especially when the insulation is very good. In speaking of telephone wires we should remember that not only is the telephone such a sensitive instrument, not only is it subject to induction and to annoyances of all descriptions, due to the presence of other wires, to earth currents, to atmospheric currents, and to currents induced by crossing the magnetic meridian of the earth, but in addition to all this they are annoyed by adjacent telephone lines. We can hear other people speak who are not connected with the same wire that we are. This is more particularly amplified in my own paper, and I think the better effect we get in rainy weather is owing to the following circumstance: that a great deal of the interference between wire and wire is due, not to induction, but to leakage along the cross-arms and through the covering, and from point of support to point of support, and this, of course, explains readily why the lines should work better and more quietly and should have less interference one with another during heavy rain storms when the supports and cross-arms and poles are covered with a surface of water; and it is not distilled water altogether, for it is pretty well charged with saline matters, and it makes a reasonably good conductor, and affords a means of escape for the induced currents and carries them away to earth at every pole, thus freeing the lines from interference with one another. A mere drizzle of rain makes a kind of a weather-cross; but, after all, the poles, so many of them, make a better conductor to earth than the different wires would.

With respect now to static and dynamic induction, I am some-

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thing of a purist in terms, and it has often mortified me extremely to hear professors of electricity, I mean practical professors, not college professors, because they are as a rule correct—talk about the two interfering effects of electricity, namely induction and retardation, whereas retardation is nothing more nor less than the result of induction; and in the prosecution of my investigations and considerations, I have about come to the conclusion that static and dynamic induction are really but different phases of the same thing. If we send a charge into an insulated conductor a corresponding charge is induced in an adjacent conductor. If we send a current into a conductor an induced current is induced in an adjacent insulated conductor, and I have come to believe that therefore the difference is nothing more than this—that dynamic induction is induction brought about under circumstances where it has a chance to flow; whereas static induction is the same thing thrown upon a body where it has not a chance to flow, and consequently must stay there. That is, static induction is merely dynamic induction in a state of rest.

Now, with respect to the lead covering. Mr. Shelbourne's paper stated that many lead cables—I think I am using his own words—have been sold to telephone companies of the roughest exterior. It is rather hard on telephone companies, but I presume he referred especially to telephone companies which are not licensed by the Bell Telephone Company, those being the ones of the roughest exterior. As a matter of fact, there have been some very bad lead cables sold; but many bad lead cables have been made and they have to be sold. The lead is generally much better than the contents. I think they would sell better if they would adorn the lead a little more; because books sell better when they are bound well although there be nothing but trash inside. As a rule, now, telephone, and electric light, and telegraph companies are more particular about the article they order than they have ever been before. Everywhere I go, I find a new thing has come up and it has been talked of; I am very chary in telling them what I think of it, because I don't know myself—well, they say, "We think it is a pretty good thing, but we want some one else to try it first." Most of the lead-covered cables, however, which are now being manufactured, are of very fair character, having high specific insulation and pretty fairly low inductive capacity; because nearly every manufacturer has found it to his interest to adopt the best methods, to use the best materials at his disposal,

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and to pay good prices for skilled labor. They found they must do it to hold their own, and whether the insulating material be paraffine or rubber, or the material which in Pittsburg they call ozite, they all try to get the best effects out of it, because if they do not they won't sell much. They may sell a cable to an unsophisticated new manager, who is in his first position, but they won't do it again; because it does not take a manager long to find out that his position depends on the cheapness and expertness with which he can get through his work. It is a fact that a lead cable placed in the earth without protection is attacked by gases. I am very glad that I can concur generally in the remarks which were given in this paper, and I think, with regard to the gases that attack lead, that it is abundantly proved that ammoniacal and carbonic acid gases attack lead more severely than any others, and when they do attack it the effect is extreme. But it is also found, and this is based entirely upon experiment and upon experience—I see it mentioned in the Brooklyn Commissioners' report—that by alloying the lead with tin these results are avoided to some extent. That is true, and by alloying the lead with antimony the same results are avoided. The lead will then stand almost any gas Limey soils, I understand, are also very hard upon lead.

Now, I can hardly agree that it is judicious that one concern, whether it be a city government or a state government, or an organized corporation, should be allowed to monopolize the conduits of a city, and say to the telephone companies, "You may occupy *those* wires and use them," and, if you are a telegraph company, "You may take *these* wires and use them, and, if you are an electric light company, you may take *these* and use them." I think it would be very difficult, if there were troubles in one wire to convince the corporation running the wire that the trouble was in the wire. It would be in the sending instrument, or in the receiving instrument, or in the lamp or dynamo, anywhere but in the wire. A case of divided command is always productive of great trouble. If one commander wants to attack, the other one thinks it is best to make a three months' siege. Every case of divided command that ever I have seen has been productive of trouble and disturbance; not only that, but this corporation would take upon itself to say what kind of insulation should be used for one class of service and what kind for another. They would take it upon themselves to regulate the thickness of the insulation. Under those circumstances, it is no wonder that telephone com-

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panies, and electric light companies, and telegraph companies, and every other sort of company utilizing electricity, should want to use their own conductors. Which of us would care to commit our property to the control of a foreign concern of which we know nothing, and, for all we know, we might find ourselves renting these wires of a foreign and inimical corporation. It would be very easy for one corporation, desirous of owning the earth, as I have known corporations to be, to own a controlling interest in the concern. In such a case it would be easy for them to do, as the Pennsylvania Railroad Co. did to the Baltimore and Ohio, during the period when the latter company advertised to run its own Washington line via the New Jersey Central. They said: "Certainly, you can have all of our locomotives and cars that you want." But to reach the Philadelphia, Wilmington and Baltimore road at Philadelphia, the trains had to pass through the Pennsylvania yard, and when we came to travel over that line we found that we were unavoidably delayed in the yard, at Philadelphia, three or four hours, and people found if they were going to Washington, or coming from Washington, they had better take the Pennsylvania trains, because *they* never had any trouble in the yards. *They* always got through on time. If I was running a company, if I was general manager of a concern, instead of being an humble official on a salary, I don't think I would want to trust my wires to any outside concern no matter how friendly they might be at the outset.

THE PRESIDENT: The experiences and conclusions of a practical man, like our friend Mr. Lockwood, are always of very great value. He has been seeking, in the course of his investigations, for the best result, and perhaps he occupies as impartial a position towards the various inventions, and methods, and systems, as any one man who has occasion to investigate them. I think he has given us some additional testimony as to the difficulty of the problem which we are attempting to solve; certainly some of his conclusions are entirely new to me, and probably to many others who are present. I would be very glad to hear from any one else who has any remarks to make.

MR. MAILLOUX: I have only one point to touch upon, which is called to my mind by my friend Mr. Lockwood's remarks, as to the analogy, if not the similarity, of cause and effect of dynamical and statical induction, and also, at the same time, to notice particularly the statement made in the paper by Mr. Shelbourne,

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about the influence of inductive capacity—static inductive capacity on the dynamic induction. Now, I believe the paper said that the dynamic induction is affected by the static inductive capacity, of the medium. Now, I do not believe that there is any experiment or any demonstration at all that would uphold that, but rather the contrary; and this leads me to say that I agree with Mr. Lockwood in the belief that electro static and electro dynamic induction are identical, when we consider them in their relation to the great law of the conservation of energy, in the relation that action is always equal to re-action; they both act and produce retardation by their re-action. There is one thing that Mr. Lockwood has not, I think, noticed; that electro-static induction is largely influenced by the electro-static condition of the surrounding medium, while electro-dynamic induction has no reference to the electro-static condition of the medium around it. We all know that electro-dynamic induction is a phenomenon which involves the action of magnetic lines of force, and that there could be no current produced if there is no conductivity; or, to put it in another way, that the amount of electrical current produced by electro-dynamic induction varies inversely as the resistance of the medium, without any regard whatever to its electro-static inductive capacity. We may consider electro-static inductive capacity as being itself a function of a certain resistance, but that resistance seems to be of a considerably different nature, involving a certain amount of molecular tension, which is probably, at a right angle. It is an action taking place in an entirely different direction from the one in which electro dynamic induction takes place. I have no doubt at all that the direction in which the lines of force are propagated axially, or the stress which is produced by lines of force in the medium is in exactly the same plane as the electro-static induction, whereas, we all know that the current itself is at right angles to that, and there is a certain relation brought out by Clerk-Maxwell and others, that bodies which are non-conductors we generally find to be of the highest electro-static inductive capacity; whereas those which are the best conductors are the poorest.

MR. MAYNARD: I would like to ask two questions. What has been the experience as to the destruction of the lead covering of underground cables, and have there been any cases where fires have been caused by the current in electric light wires laid underground?

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THE PRESIDENT: Can any one present give us any information on those points?

MR. MAYNARD: The first question is in regard to the lead covering of cables laid underground being injured by ammonia and carbonic acid. It is well known that those gases will destroy it, but what has been the experience, how long does it take?

MR. MAILLOUX: I remember distinctly that at the first meeting we had here in this room there were exhibited on that shelf a large number of samples of lead pipe and there were labels on them the same as on these samples. The degree of oxidation was of course shown by sections of the pipe, and I saw pipes there that had been used for carrying water for something like forty years, and which were apparently not at all harmed, having evidently suffered only a very slight disintegration. It appears to me like a sub-oxide of lead, or perhaps a form of carbonate, which had formed in the interior of the pipe, and yet the process did not appear to have extended sufficiently deep to impair the utility of the pipe. If a pipe can stand usage for forty years in carrying water, it ought of course to be able to stand usage for a long time in carrying electricity, provided we get it in the same condition. I do not know very much about the corrosion of pipes by ammonia gases and carbonic acid gases, but I should imagine there might be something of that nature. Some years ago, in working storage batteries, I had occasion to go into the corrosion of lead deeply, and there was at that time a great deal of discussion going the rounds of the journals in regard to the formation of sulphate of lead in storage batteries. Perhaps you may not see the evident connection between sulphate of lead and carbonate of lead, but, as I understand the chemistry of it pretty well, I can see that there is a great connection between the two. For a long time we were troubled with sulphate of lead forming in the batteries. In a short time sulphate of lead would have eaten up the plates, and would have produced a form that would have ruined them, and it was a very troublesome thing to deal with. The battery became useless very quickly, and there was no means of remedying it, and it was not discovered until a long time after, as the result of some chemical reasoning, simply that the thing was produced by some acids contained in the solution used. Some advocated a stronger solution of acid, others a weaker solution. But the jist of it turned out to be this, that in the ordinary sulphuric acid of commerce there was a slight amount of nitric acid as an

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impurity. In the making of sulphuric acid they use nitric acid, which becomes converted into nitrous acid, and immediately takes another molecule of oxygen from the air and becomes nitric acid again, so you could go on indefinitely making nitric acid. Carbonic acid will not attack lead of itself. You may put a piece of lead in a solution of carbonic acid in water, or else put it in carbonic acid gas, and it will stay there an indefinite time without manifesting any change at all, but if there is some substance like nitric acid, which can oxidize lead and convert it into a nitrate, then almost any acid that happens to be lying about, and in this case carbonic acid, would be likely to attack it. So I don't doubt at all that the ammonia furnishes the nitric acid, in combination with the oxygen of the air, which produces the disintegration of the lead, and the carbonic acid takes hold, and forms a new combination, and leaves these other elements there to go on again for ever. So it appears to me if we put in a substance like antimony or tin, as Mr. Lockwood says, that it is not so likely to form stable compounds with nitric acid. I have no doubt at all that nitric acid is the thing we have to fight in the lead pipes. I think that if experiments are made with a view of tracing it to nitric acid, we will find out that that is the trouble, and, if we do find out that that is the trouble, we shall have made a step toward finding a remedy.

MR. LOCKWOOD: These remarks of Mr. Mailloux seem to me to accord very well with the text given us in Mr. Shelbourne's paper. He says, however, in respect to the pipes he saw in this room some time ago, that because they worked so well with water so many years, they ought to work well with electric wires. The doctrine of *ought* is very good, but it does not work in practice at all. We know there is another doctrine, namely, the depravity of inanimate things, which comes in there. The fact is that the very deposit on the interior of lead pipes, caused by the water, acts as a preservative. As far as the outside of the pipe goes, it depends altogether on two things—first, the nature of the soil, and secondly, the nature of the attacking agent. Not very long ago the Western Union Telegraph Company seized upon a street in Boston called Friend street. It is not much wider than this room, and the side-walks take up one-half the street. They put up one of their enormous lines of poles there, with the cross-arms, and a great number of wires outside the windows, and the tenants made a great cry about it, as they ought to have done. The Western Union

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thought, as they put up their poles in the night, that possession was nine-tenths of the law, and that they would be able to keep them there. But the popular voice was successful. Property owners said they might go on the roofs if they wanted to, but they declined to do that, and went underground with their wires from State street through Friend street. Now, everybody who knows anything about Boston, knows that Friend street is lined with stables on both sides. These wires, of which samples were shown to me, were encased in lead, and it is not more than a year since they were laid down. The specimens they pulled up are very badly used up already. It must be owing to the refuse of the stables soaking the earth with these carbonic and ammoniacal gases which tend to form nitrates. These must be the "stable" products that Mr. Mailloux spoke of. (Laughter.)

MR. MAILLOUX: It strikes me that Mr. Lockwood had to lead his horse through a great many turns to get to the stable.

MR. SHELBOURNE: I am able to say in regard to this Brooklyn case that these cables, as I understand, were down some eighteen months. They were placed in the streets about the City Hall. The statement about them, which came from the Brooklyn Commissioners, was not correct. Of course they got their information from other persons, and perhaps were misinformed. I consulted Mr. Sargent about the conditions and facts of the case, and he gave me the exact particulars as he had learned them. This carbonate of lead appeared from these cables where they left the conduit, while being pulled out of it, and as Professor Plympton told me, this carbonate was picked up by the handful on the spot. I found, as against the theory of the water gas acting upon it, Mr. Sargent said that where the water gas escaped the most perceptibly, that is where the cables from the conduit entered the building of the Exchange, that there was no action upon them at all, showing that we must look for some other reason for the carbonate of lead than the action of carbonic oxide in the water gas. Now, if the carbonic oxide escapes from the pipes into the soil—it is well known that carbonic oxide is very light—it has about three-fifths the specific gravity of carbonic acid—carbonic acid of course being much heavier than air—it is apparent that the carbonic oxide, or monoxide, not being absorbable by water in the soil, on escaping from the pipes, would directly find its way out of the soil and rise in the air. The statement in regard to the wires in Friend street, confirms what

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the analytical chemist says in his memorandum. It is not that the carbonic acid acts by itself upon the lead, for it will not; but, as that memorandum maintains, the animal manures penetrating the soil and the decayed vegetable matters produce nitrate of ammonia. Then the action on the lead is not direct, but there goes on a series of actions and re-actions till the result is the carbonate of lead. There are two or three actions and re-actions which take place, and which are quite intricate in the ordinary production of white lead. The ammonia nitrate is the first thing that is produced from these soils. Nor is it competent to the direct oxidation of lead. Lead does not oxidize under such conditions. Lead nitrate is first formed and then the oxygen of the air brings in some of these intermediate actions and re-actions in connection with carbonic acid which result in the production of the carbonate of lead. Mr. Sargent exhibited to me a piece of cable that was brought out of the pipes, and while it was very evident that corrosion had taken place from the pitted condition of the surface of the lead; yet, from the amount of waste or disappearance of the lead, as I could judge, that corrosion might have gone on perhaps for eight or nine years before the lead would have entirely disappeared. Another element enters into it. As the coat of carbonate of lead becomes thicker, it protects the metallic lead beneath it from further rapid progress of the corrosion.

In regard to the question about adulterating the lead with tin, etc., I was aware that the purer the lead the more readily it would be acted upon under such conditions. When I was a student in college, it was stated to the class in chemistry, by Professor Silliman, that rain water affects lead very readily, and the purer the water the more rapid the action; but, if you want to corrode rapidly a lead pipe, put it in a drain where it gets water impregnated with all the refuse of decaying vegetable matter; but as to the question of the cost of that tin adulterant, that is of some importance. If lead is taken at four cents a pound, suppose it requires three per cent. of tin, and metallic tin costs four or five times as much as lead; therefore, the cost of the tin would be a very considerable element. The tin, of course, was spoken of in the report of the Brooklyn Commissioners, and afterwards mentioned to me by Professor Plympton. I said that the cost of the tin required to enter into one hundred pounds of lead, would be something like sixty to sixty-five cents. I also mentioned to him the substitute Mr. Lockwood spoke of, antimony; and I also sug-

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gested, as a preventive of the corrosion of the lead covering of cables, the adulteration of the lead with metallic arsenic, which we can buy at five cents a pound. Now, that is as far as I think I am able to answer Mr. Maynard's question.

In regard to another point discussed by Mr. Mailloux and Mr. Lockwood, that is, the distinction between dynamic and static induction, of course, when induction results in currents which interfere with clear and distinct service in the telephone, we understand that is dynamic induction; but as to the fact of there being no conductor outside of the insulation as remarked by Mr. Lockwood, as to static induction, to receive or carry away the current, look at the conditions in the Atlantic cables. There, outside of the gutta percha, you have the whole ocean to carry it away. Again, it is shown by the experiments, I believe, first of Sir William Thompson, in regard to the early Atlantic cables, that retardation was the same, whether the battery used was ten or a hundred cells. They first tried, in the cable of 1866, to get over sluggish action of the electric current by increasing the size of the battery. I believe they used as many as a hundred to three hundred or more battery cells upon that cable, and also dynamo machines.

A MEMBER: They used strong induction coils.

MR. SHELBOURNE: Of course you have there the gutta percha core of the cable surrounded by the whole ocean. The armor and the jute put around the core of the cable do not, of course, prevent the salt water from getting right in next to the core, conconsequently you have there the favorable conditions of static induction. The conditions are exemplified by the Leyden jar. Now, if the induction is greater—static induction—there being no surrounding conductor to carry it away, why then you could get a charge into a Leyden jar greater, when there is no connection with the earth, than you could if there be such connection. It is found, however, and laid down in the books that in the Leyden jar, if you do not connect the outside tin foil with the earth, you can get but a very slight charge. If you do connect it with the earth, the action and re-action goes on till the greatest possible charge is obtained under the other conditions present. Therefore, it seems to me, that there must be a distinction taken between the conditions of the action and re-action of dynamic induction and of static induction.

As to the better effect of iron than other metals as a screen of

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induction connected with the insulation of the single wires, that was a point that I did not touch upon, and if Mr. Lockwood made his remarks, as based upon my paper, he misapprehended it. I very early became convinced that there was an additional effect to be produced by the use of iron as an immediate screen instead of any other material, but the difficulties in that case are so great mechanically as to make it impracticable. I took out, some years ago, a patent that was related to that subject, in which I claimed the use of the magnetic oxide of iron as an induction screen; but it is practically of no value, because under the conditions where it would be necessary to use it instead of the ordinary tin foil it would take up so much space, that for the benefit it would give, it was impracticable. My remarks as to the case were upon the use of iron as a conduit in which a large number of conductors or cables might be inclosed. Now, the statement is that such an iron conduit, in which lead covered cables are used, would cause retardation in the cables within it—I do not admit such a statement to be true, as we understand and speak of retardation being the result of static induction. In the beginning of the underground telephone business in Brooklyn, some persons who proposed to do some of the underground work —Mr. Sargent, as stated by Prof. Plympton to me,—wrote to Mr. Preece about the sort of conduits he would recommend; and Mr. Preece replied that these wooden boxes creosoted, he did not find advantageous, because he found that the coal tar or creosote would act upon the gutta percha insulation, and therefore, they didn't think of using them, and he concluded his letter by saying, "Why don't you take the ordinary iron pipe? That is a thing there will be no question about."

MR. LOCKWOOD: Would you put the entire pipe immediately in the trench or ditch in contact with the earth?

MR. SHELBOURNE: Certainly. The iron in such a case, being in contact with the earth, can only act as a conductor away to the earth the same as any other metal would do. There are, however, probably dynamic reactions that would take place between the iron pipe and the conductors, due to magnetic variations produced in soft wrought iron pipes, by the make and break or rapid variations of the currents in the conductors.

MR. LOCKWOOD: I think you are quite right, but there is this to be considered—if the enclosing pipe, be it iron or any other metal, be in direct contact with the earth, it virtually surrounds the con-

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ductors with the earth, and, therefore, they are more exposed to the retarding influences of the static induction.

MR. SHELBOURNE: That is, so far, true; but I also spoke of the wires that were in the individual cables inside of the conduits being in contact with the earth, that is, in grounded circuits. In such cases, when those wires are not in use, and other of the wires in the cable are in use, those not in use admit the access of the inductive nearness of the earth in the same manner, and, perhaps, in even a greater degree than the conduits. There was one further consideration in regard to that, and it is this—so far as dynamic induction currents are concerned, we will suppose that the earth is in a condition of dryness around these pipes. Then the result of dynamic induction, from the cables in the one to reach the cables in the other, if the iron pipes are alongside of each other, and not touching, would be that the conduit itself—the iron pipe itself—would take up the current of induction, and if the earth is dry between them the pipes would carry the currents to some point on the line where the earth is wet. But the iron pipe would not afford any more formidable conditions of static induction than any other conductor, wet earth for instance. Now, it is found by the Commercial Cable Company that they get a greater charge in the wires, in other words, the conditions of static induction are greater when there is water in the earth, sufficient to go through the armor of the cable and thoroughly wet the jute under the armor, and hug, as it were, the insulation of each of the conductors, and thus afford the better conditions of static induction between the outer surfaces of the insulation and the wires within the insulation.

THE PRESIDENT: The Chair regrets to say that, owing to the lateness of the hour, it will be necessary to curtail this very interesting and instructive discussion. And if any other gentleman has further remarks to make, I hope he will be as brief as possible.

PROF. YOUNG: I had charge of a lead pipe aqueduct in Hanover, in New Hampshire, that was laid in 1810. It runs through the village, and every now and then it comes up in people's barn-yards, and in the barn-yards where it comes up it lasts about five to six years. I had to replace some three or four of them in the twelve years I had charge of them. The pipe was inch and a-half pipe, and was perfectly good, except at some places where it crossed a road or went under barn yards.

MR. MAILLOUX: It does not matter at all whether the earth

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touches the iron pipes or not. If a current passes through them is of a wavy nature, as it would be in telephone transmission, the current, as the wave rises or falls, would produce a change of magnetic condition in the conduit, and it is well known that the magnetic field around a conductor expands and contracts as the current rises and falls, and that each one of those expansions or contractions would tend to magnetize the conduit at that particular point where the wave happens to be in circumferential direction. Now, as this thing gets magnetized, it would exert a reaction on the impulse itself, and it doesn't matter whether it is one part of the conduit acted upon or two parts of the whole length.

THE PRESIDENT: In closing this discussion, I might mention one little thing which I happen to have read, that throws a good deal of light on the great durability of lead underground under favorable conditions. Long ago the early French explorers of the western country, I suppose one hundred and seventy-five years at least—I do not recollect the date exactly—in taking possession of the land on behalf of the French government, were accustomed to bury at the intersection of the principal rivers a lead plate with an inscription engraved on it, stating that the territory was taken possession of in the name of the king of France, etc. It is only a very few years since one of these plates was dug up, at the junction of the Ohio river and one of its branches, somewhere below Pittsburg, and the plate was found in a very perfect state of preservation. It was corroded but little and the inscription was perfectly legible, which, I think, is very strong evidence of the great durability even of the surface of a leaden body under favorable conditions.

The SECRETARY: Before the discussion closes, I would say, in reply to the inquiry of Mr. Maynard, as to whether fires had originated from arc lighting wires underground, that I have kept pretty close track of that branch of the subject, being on a committee of the Electric Light Association, and no case of that kind has come to my knowledge. But this may arise from the fact that there is but a very limited number of arc lighting wires under ground at the present time. The wires in Chicago are confined to isolated plants. There is no central system of street lighting as in this city; and with the exception of the wires in Chicago and those with which he is familiar in Washington, I believe there is nothing else in the way of underground arc lighting wires, ex-

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cepting a system which has recently been established in Detroit by the Thompson-Houston, and that has been in operation only a short time, and therefore I have no information regarding it.

CAPT. MICHAELIS: I would like just to say a word, in confirmation of the Chairman's remarks in regard to what I might call the chemical refractoriness of lead. The Government had stored all over the country thousands and thousands of pigs of lead under all conditions, some of it in cellars. I have seen some in Fort Carroll, where it was exposed to spray, and I never saw a pig of lead that appeared to have degenerated in any manner whatever. Yet, not long ago, I had occasion to examine about twenty tons of English bullets that had been stored in a dry place, and they presented every sign of degeneration. They were incrusted with carbonate, and I have been led to think that this apparently inexplicable degeneration of metal is due to galvanic action, and where the lead is pure, and we used to get pure lead years ago, that this action is not so apt to take place as it is with bullets, which we know contain not only oxide of lead, but other metals, zinc, tin, etc., and there you have a favorable condition for galvanic action; and I have no doubt, where there has been marked degeneration of lead pipe, that it may be due to the impurity of the lead and the consequent galvanic action.

THE PRESIDENT: We will now listen to a paper by Prof. William A. Anthony, of Cornell University, on the great tangent galvanometer which he has recently constructed there, which in the absence of that gentleman will be read by the Secretary.

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THE GREAT TANGENT GALVANOMETER OF THE CORNELL UNIVERSITY.

BY PROFESSOR WM. A. ANTHONY.

THE "mammoth tangent galvanometer" which was described in the *Electrician and Electrical Engineer*, of October, 1885, has now been in use for nearly a year, and it may be of interest to the Institute to hear a brief account of its working. It will be remembered that the instrument was constructed primarily for the direct measurement of large currents, and its large dimensions were necessary to adapt it to that purpose. At the same time it is possible to measure by means of it, currents as small as 1-100th ampére. The instrument is fully described in the *Electrician and Electrical Engineer*, but a description is given here in order that the various uses to which it has been put may be better understood. The needle is made of a number of thin wires, is hung in a copper block, and is very nearly dead-beat. The apparatus for observing deflections, gives these accurately to 20 seconds. The coils for heavy currents each consist of a single turn of copper rod 1.9 cm. diameter. There are four coils, two of them 200 cm. and two 160 cm. diameter. These are placed parallel to each other, the two coils of a pair being at a distance apart equal to their radii. As the coils can be used in series, in pairs, singly, or differentially, it will be seen that the galvanometer may be equally sensitive to widely different currents. In fact, currents of any value from 4 to 250 ampéres, can be measured by deflections of the needle never less than 25 nor more than 60 degrees. Four coils of 18 turns each of small wire, serve to measure smaller currents. The instrument has been used for measuring currents of dynamos under test, for measuring currents, for standardizing other instruments, and for a great variety of experimental work.

Its indications have been compared with those of the copper voltameter, with generally a very close agreement. The disagreements that have been observed, have been traced to irregularity in the action of the voltameter. It has also been compared with a calorimeter with very satisfactory results. All the observations that have been made with it, go to show that its indications may be implicitly relied on. In fact, those who have used it, have come

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to feel the same confidence in the results obtained, as when weighing a body on a good balance. In the use of the instrument, readings can be taken very rapidly, ten minutes sufficing for twenty readings which are ordinarily taken as a set in measuring currents, and the computation of results is extremely simple. There are no temperature corrections except where the highest degree of refinement is aimed at. The only correction that need to be considered in any ordinary case, is that due to variations in the horizontal intensity of the earth's magnetism, and the instrument contains within itself the means of determining the horizontal intensity at any time.

The advantages of the galvanometer over other methods of measuring large currents, will appear by considering the sources of error or uncertainty involved. Currents may be measured by shunting a smaller tangent galvanometer. Here the errors depending on the instrument itself are the same as for the larger instrument, but larger in proportion, since the dimensions of the smaller instrument cannot be measured with the same percentage of accuracy as of the larger. But in addition to these, there is the uncertainty in regard to the shunt ratio, which depends upon temperatures very difficult to determine accurately. With copper conductors, a change in the ratio of one per cent. would result from a difference of temperature of a very few degrees.

Theoretically, the best way to measure currents would be by reference to their own mutual action. That is, by means of some form of the electro-dynamometer. But any such instrument, when constructed for measuring large currents, involves large sources of error. The instrument must be of large dimensions, otherwise the cross section of the conductors will be large in proportion to the distances between them, a condition which makes it impossible to determine the constant of the instrument with certainty. The forces to be measured are very small, and any arrangement for carrying the current to and from the movable coil, must seriously interfere with its freedom of motion, and so impair the sensitiveness of the instrument. The writer of this paper had planned to construct a dynamometer in which a movable coil should be suspended from the arm of a balance, and the force exerted between it and the fixed coil, *weighed*, but no method could be devised for reaching the suspended coil with a current of 20 ampères even, without a loss of sensitiveness that was fatal.

Currents may be measured by determining the deposit of cop-

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per or silver. In theory this is very simple, but in practice, constant results can be obtained only by observing many precautions, and even with the greatest care, results will sometimes differ by one or two per cent. from the truth, without apparent cause. Moreover, these voltameter methods are not generally available, as they require too much time, and give only a time integral of the current, and not its value at any given instant. They are only of value for the calibration of instruments whose constants cannot be determined from their own dimensions, such as the various forms of ammeters, including the so-called "Vienna method." The indications of all such instruments are uncertain, unless they are frequently calibrated. If permanent magnets are used to produce a magnetic field, they are liable to a continuous change, and they always change in strength with change of temperature. If any of the forms of mirror galvanometer are used, as in the "Vienna method," the slightest change in the position of the needle with reference to the small coil, such as might occur from a stretching of the fibre, will change the constant.

To sum up: The tangent galvanometer is a very sensitive instrument, and its constant depends only upon its dimensions and the horizontal intensity of the earth's magnetism. Temperature affects the constant only as it affects the dimensions of the instrument. For the shunted galvanometer the constant depends upon the same elements, with the addition of a very uncertain shunt ratio.

The voltameter is usually inadmissable for direct measurements of currents, and the method requires extreme care to avoid errors in determining the deposit, which errors may arise from some of the solution being occluded in the deposited metal, or from loss of the metal while washing, or from other causes, difficult sometimes to assign. Moreover, this method is not an *absolute* method. Electrodynamometers, when constructed for use with large currents, lack sensitiveness.

Of course, the large tangent galvanometer is not a portable instrument. Few instruments of precision for absolute measurements are. It must be mounted in a place free from local magnetic disturbances. But it is the conviction of the writer, after extended experience, that, for purposes of accurate testing, or for standardizing other instruments, there is no other method for measuring currents, so reliable, so accurate, and so expeditious.

PHYSICAL LABORATORY OF THE CORNELL UNIVERSITY, *May 15th*, 1886.

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THE PRESIDENT: The measurement of heavy electric currents, such as are used for lighting and power, is almost a new subject, and perhaps the first work that has been done in that line approximating strict accuracy is that which has been accomplished by means of Prof. Anthony's galvanometer, which he has spoken of in this paper. If there are any present who wish to make any remarks they have an opportunity.

MR. LAIN: As I had the privilege of being in attendance at Cornell the year in which this instrument was built, though it was also my misfortune to be obliged to leave the University, since I graduated last June, just before the instrument was in successful working,—in Prof. Anthony's absence I may be able to say something about it. A description of the instrument has, perhaps, been read by most of those present, but the way in which Prof. Anthony removes the errors of construction and errors liable to arise from surrounding influences certainly deserves some mention. In the first place, he received a large appropriation for the instrument and its appurtenances, and a house was especially built for this one instrument, a small frame house, in the construction of which not a particle of magnetic metal was allowed. The nails used were all of copper, the hinges were of brass. A copper stove was built especially for it and a copper stove pipe, and the gas pipes leading to it were of lead instead of iron, and then, as will be seen by the description in the *Electrician and Electrical Engineer*, the mechanical construction of the instrument is such that the errors of construction are removed almost entirely. Then Prof. Anthony speaks of the errors in the use of the copper voltameter. I chose that subject for a thesis last June, and was very much surprised at the obstacles I met in working it. I started out with something like twenty-four cells in series, and whenever one cell was stopped of course they would all be stopped, and the current started on one of them would also pass through each one of the others; and I found by taking the greatest possible pains that the discrepancies in the increase of the deposits on the negative plates were much larger than I anticipated. These arise from a variety of causes. In the first place, there is the addition of the salt of the liquid—the sulphate of copper—to the plate, which is accidental, and therefore irregular, that is, it appears that the liquid is built in with the deposit. Well, whatever liquid is built in in that way adds to the

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weight, and therefore makes an error in the computation. First, I thought it sufficient to simply allow the plates to be nominally dried before weighing them, but, after experimenting for a long while, I found that I obtained quite different results, if the plates were desiccated before weighing; so that the conclusions I arrived at in my thesis were that unless there was some arrangement—some acidity of solution, such that the amount of the metal removed by the chemical corrosion was exactly equal to the added weight due to this imprisoned salt—unless this should be arrived at, the voltameter would show results that were not accurate.

MR. MAILLOUX: I would like to add in confirmation of the gentleman's experience, that for the last year I have been devoting my time almost entirely to working copper, and one of the first things I found was that there was almost an impossibility of making a relation between the amount of copper deposited and the amount of current passing. The books state that one ampere of current passed through for 386.4 hours will deposit a pound of copper, but I confess I have never made practice come to theory or agree with it. I was working for industrial purposes, one of which was electrotyping, and I have come to the conclusion that a great many of the determinations that have been made by means of the voltameter, using copper, and even silver must have been erroneous, and as the gentleman says there are some obscure causes involved, one of which he has brought to notice and another one which I think has not been mentioned before, and which is the occlusion of hydrogen by the metal itself. I had found that out practically by experiments. If a solution is not of the right constitution, instead of depositing copper you are depositing copper and hydrogen, and when you come to weigh the copper you weigh only the copper; you have no means of estimating the amount of hydrogen that is occluded there. As a matter of fact, you would never know there was hydrogen there. It took me a long time to surmise that hydrogen was there. It is said you get evidence of hydrogen when the copper is granulous—black. I have found hydrogen when the copper was perfectly regular, perfectly good and clear. I have deposited two pieces of copper and at the end of a week one would be perfectly rotten and the other as hard and tough as hammered copper, and that, I think, is one of the sources of error which make the copper voltameter utterly unreliable. I think that some form of tangent galvanometer, which gives the thing an absolute

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measurement taking the earth's component of magnetism as the starting point, is probably the most satisfactory thing you can get.

THE PRESIDENT: I have observed for a long time that the confidence of experimenters in the results obtained with the voltameters were apt to be in the inverse ratio to the amount of their experience with it. Mr. Edward Weston, who I am very sorry not to see here to-day, has done a great deal of practical work in electrolysis and electroplating for many years, but has never been able to get any results which he had any particular confidence in, and his confidence has diminished the longer he has gone on. I have talked with him about it a good many times. I very much regret he is not here to give us the benefit of his experience, but it accords very closely with that of the two gentlemen who have last spoken, and of others that I might mention, and I think we might consider that it is pretty well established that it is not safe to place any very great confidence in the results obtained by the voltameter unless checked by independent sources.

PROF. YOUNG: I was going to say there was one peculiar experience of Prof. Anthony which he does not speak of in this paper, namely, that the stiffness of the suspended wire is all the time increasing and the time of the vibration of the needle is increasing. I wonder whether others have come upon that same thing. I have found that the springs of our clocks at our observatory at Princeton are growing stiffer. Our mean time clock has certainly in that way increased its rate as much as some few seconds a day, in the last few years, I suppose from the increased hardening of the springs. Prof. Anthony finds it necessary in his galvanometer to check this co-efficient of torsion.

THE PRESIDENT: That is a very interesting observation of Prof. Anthony's and should be borne in mind.

THE SECRETARY: It has occurred to me that as one of the blessings which we were to derive from incandescent electric lighting was the reliability of the electric meter, which I believe is based on this principle of depositing copper, it would be quite interesting to know if the error alluded to would be in favor of the consumer or the producer of the electric light.

MR. LOCKWOOD: I would say, Mr. President, that is a question that will always answer itself, the same as the gas meter does.

THE PRESIDENT: I believe that the actual method adopted and practised is a zinc voltameter. It has been stated in accounts

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which have been published of the central station lighting systems of this country in which this method of measurement is used, that the results are accurate within one per cent. I think there can hardly be any doubt that this is somewhat of an exaggeration, because I fancy it would be difficult to get that result in a laboratory every trial with all the time required to make the measurements. But it is very probable, I should think, that the results might be depended upon within four or five per cent. I should be very glad if any one present could give any information on that point. It is a matter of a good deal of practical interest. If there are no further remarks to be made on this paper, I would say that a little collation has been provided, and we will now take a recess of an hour to discuss that, after which we will listen to a paper by Mr. Thomas D. Lockwood, of the American Bell Telephone Company, on "Some Recent Advances in Telephony."

A recess was then taken.

The afternoon session convened at 2.15 o'clock, when Mr. Lockwood read his paper.

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SOME RECENT ADVANCES IN TELEPHONY.

BY THOMAS D. LOCKWOOD.

TEN years ago a meeting of the American Academy of Arts and Sciences was held in Boston, at which Alexander Graham Bell expounded his ideas upon the electric speaking telephone.

Prior to that date, a patent had been issued to the same gentleman upon the same subject; a patent which many persons state they have since ascertained refers in no way whatever to the speaking telephone; a statement which many other persons, perhaps equally well informed, believe to be based upon a wish that such were the case.

The first line built between two distant points expressly for telephonic transmission, was completed April 4, 1877, and extended from the office of the electrical manufacturer, Mr. Chas. Williams, Jr., 109 Court St., Boston, to his house in Somerville, a distance of about three miles.

May 1st, 1877, the first lease of telephones for private line service was effected; and in May, 1877, telephones were first operated upon the exchange plan, through a switch board in the office of Mr. E. T. Holmes, 342 Washington St., Boston; the sub-stations comprising a number of different offices connected with the Holmes burglar alarm system by wires converging to Mr. Holmes's office. For a number of years it was assumed that the exclusive field of usefulness for the telephone, like that of the average and proverbial specimen of charity, not only begun, but also ended at home; that the local short line, or exchange service, was the only kind in which telephones could, or would be practically used. Recent experience proves this assumption as hardly correct. The exchange, or central office service, it is true is the more immediately practical and obvious utilization, and it was natural that the American people should measurably fill that sphere of action before looking for others, inasmuch as that was the line of operation promising the most speedy pecuniary return for the outlay. Lines of from a few yards, to a dozen miles in length have, however, been connected with exchanges, and these have in turn been supplemented as occasion served, by what are technically termed extra territorial lines; that is lines connecting different exchange centres; and from 1879 to the present time it

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has been a regular practice to talk over such lines with comparative ease, perhaps for an average distance of 40 to 50 miles. In some of the western states it has been a common thing to converse by telephone over much greater distances, by switching lines together, but not always with ease.

I think it well understood now that three conditions have conspired to retard what is at present termed long distance telephony. These are:

(*a.*) The uncertainty of obtaining satisfactory and speedy reciprocal communication, and the consequent slowness of transmission together with the inevitable result of such uncertainty, namely, the low prospective maximum capacity of remunerative transmission.

(*b.*) The extreme noisiness of long lines, and increased telephonic induction, or cross talk, which in many cases renders the single or earth terminal circuit insufficient.

(*c.*) The lack of transmitting instruments sufficiently powerful and trustworthy to develop voice currents capable of overriding the undesired currents and the noises produced thereby, and of sufficient E. M. F. and volume to affect the distant receiver with clearness and strength.

If it be asked at the present time "what is long-line telephony?" I answer—"Telephonic communication over lines more than 50, and less than 500 miles long." Six years ago I should have limited it to lines between 20 and 50 miles long; and six years hereafter I may possibly fix the limits of long-line telephony between 250 and 1,500 miles. The term is purely comparative.

The most noteworthy advance of the telephone in the past few years has been in the direction of increasing the distance over which communication can be transmitted satisfactorily, and the advance which has been made is, I think, undoubtedly attributable to the introduction of copper line wire, and to the radical improvement of the transmitting telephone.

It must not be supposed that telephone communication over long lines was until recently entirely unknown, even when we accept the above definition of a long line.

On the contrary, it is a well authenticated fact that in the earliest days of the speaking telephone, time and space were well nigh obliterated.

In the remote period when the magneto speaking-telephone

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was the only known—and was itself a new and wonderful thing —it was operated over lines of (for that time) really considerable length. On August 11th, 1876, for example, conversation was carried on at Brantford, Canada, over five miles off, between Brantford and Mount Pleasant, and on the succeeding day the length of line was increased to ten miles.

As early as November 10th, 1876, a very long line was successfully used. I find among the early records of telephony the following statement: "November 10, 1876. "We carried on a long "conversation on the lines of the Eastern railroad, using part of "the time a circuit from Boston to Salem, 15 miles; and part "of the time a circuit from Boston to North Conway and back to "Salem, and from Boston to Portland and back, about 200 miles "of actual wire."

This statement is made by Mr. Watson, (who like De Sauty, was long supposed to be a suppositious character, being always at the other end of the line) and is noticed in the Boston *Post*, *Globe*, *Advertiser* and *Herald* of November 27, 1876.

In the early spring of 1877, with a box and magneto telephone, Mr. Bell in New York, conversed with his associate in Boston on a Sunday, and he speaks of the occasion in the following words:

"The longest length of real telephone line through which I "have attempted to converse has been about 250 miles."

"On this occasion no difficulty was experienced so long as "parallel lines were not in operation. Sunday was chosen as "the day on which it was probable other circuits would be at "rest. Conversation was carried on between myself in New "York, and Mr. Thos. A. Watson in Boston, until the opening "of business upon the other wires. When this happened the vocal "sounds were very much diminished but still audible."

"It seemed indeed like talking in a storm. Conversation, "though possible, could be carried on with difficulty."

There are in fact a number of such isolated cases and I have thought proper to refer to these as showing that the idea at least is old, and that the magneto telephone is not an utterly incapable instrument, even viewed as a transmitter. There is, however, a wide gulf between an occasional successful experiment, made under favorable conditions in which experts can understand one another, and regular every day successful commercial communication.

If by recent developments this gulf has not been permanently

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and solidly bridged, there has at least been a convenient and useful ferry established.

Before leaving the early years of the telephone, it may amuse, if it does not instruct, to refer to an item which appeared in the *Scientific American*, on November 29, 1879, entitled "How far can we hear with the Telephone?"

"This is a question frequently asked, but one which we believe "has not yet been definitely settled. The longest distance that "we have seen mentioned, is given in the item below, namely, "two thousand miles. But perhaps Mr. Edison has had more "extended experiences. If so, we should be glad if he would "let our readers know. An exchange states that Mr. Robert A. "Packer, superintendent of the Pennsylvania railroad, is at pre-"sent hunting with a party of gentlemen in Nebraska. A few "days ago he for two hours conversed pleasantly with his wife "and friends at Sayre, Pa., his brother at Mauch Chunk, Pa., and "his friends along the line. The medium was the railroad and "Western Union Telegraph wires, and Edison's telephone. At "the office in Bethlehem, Pa., connection was made with the "Easton and Amboy wire, and at Perth Amboy with a Western "Union wire and thence to Chicago and North Bend, Nebraska, "where the party are. The distance was about two thousand "miles and every whisper was audible."

Now if there is anything in the world that annoys one, it is to hear an apparently trustworthy account of something being done in one's own special line of work which, with every appliance for the purpose, with experience and special education, we cannot do ourselves. It is not therefore speaking too strongly when I say that this statement both mystified and exasperated me, for I knew certainly that at that time I could not accomplish such a feat; but I possessed my soul in such patience as I could make available and awaited developments; having at least a suspicion that there might be an error in fact, seeing that the veracious chronicler had already committed himself to the statement that Mr. Packer's business relations were with the Pennsylvania railroad instead of the New York and Pennsylvania Canal & R. R. Co., as it should have been. I had not long to wait however. In the issue of December 27, 1879, a second item appeared entitled "Long-Range Telephoning" (I think the original one should have been called "Long-Range Reporting,") which read as follows:

"In a recent issue of this paper an exchange was credited

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"with the statement that Mr. Robert Packer, while traveling in "Nebraska, had conversed with his wife and friends at his home "in Sayre, Pa., two thousand miles distant, by means of a tele- "phone. We now learn on good authority, that though Mr. "Packer's friends received his communication by telephone it "was not so sent by Mr. Packer. The message was sent from "Nebraska to Mauch Chunk, Pa., by telegraph; thence it was "telegraphed to the Sayre office of the Pennsylvania Canal Rail- "road Co. (of which Mr. Packer is superintendent), and from "there it was transmitted to Mr. Packer's house by telephone, "falling short of the newspaper report of the telephone's per- "formance by some nineteen hundred and ninety-nine miles and "a fraction."

Such is a sample of the long-range telephony of 1879.

When in the summer of 1879 a telephone line of two wires was built between Boston and Lowell it was regarded as a great achievement; for it worked well. It, however, epened our eyes to the phenomenon of induction in another phase to that in which it had heretofore been made manifest.

That phase in fact which in more recent times has been named "cross-talk." We found that when conversation was transmitted upon either wire, it would be heard equally well upon the other at the receiving station, and until many other lines were built, it was found practically impossible to operate both lines at once.

This was the beginning of lines to connect distant telephone exchanges and the seed from which sprouted the long-line tele- phony of to-day. When, however, the value of copper as a ma- terial for line wire was recognized, the commercial feasibility of long-line telephony, as above defined, became a subject of serious consideration, and exchanges located 75, 100 and 150 miles apart, were brought into conversational proximity.

The possibilities of the telephone were never brought before my mind in so striking a manner as when I stood in a little room on Broadway in this city, and talked with a fellow mortal in Cleveland, Ohio. Many of the members of this Institute will, doubtless, remember that when the compound wire of the Postal Telegraph Co. was built, and communication over it completed in 1883, first to Cleveland, and later to Chicago, a noble army of telephonic patentees hastened to try their patented telephonic re- ceivers and transmitters over it, and how each and all, after suc- cessfully exchanging words with the western cities, went forth

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proclaiming to the world the unparalleled excellence of their special form of telephone.

When I first heard these statements I was firmly convinced that the achievements described, were due not to any special excellence of the instruments employed, but to the greatly superior conductivity and insulation of the Postal wire over any other that had heretofore existed, and my conviction was intensified after I had had an opportunity to make the test myself and had found that, not only could we make a Blake transmitter transmit speech which was perfectly reproduced at the receiving station, but that identical results could likewise be achieved with the magneto Bell telephone commonly used as a receiver.

To Mr. Thomas B. Doolittle, of Bridgeport, is due the credit of having first discerned the merits of copper as a material for telephone lines. A line of hard-drawn copper was erected by that gentleman in November, 1877, in Ansonia, Connecticut, a section of which was taken down in August, 1884, and found to be, when compared with any iron wire of like age, in an excellent condition. I may also say that from the first moment of my acquaintance with Mr. Doolittle, I have found him a strong and persevering advocate of copper wire for telephone lines, and, considering our present views upon the relative merits of iron and copper, it is fair to say that I think he has made out his case and was considerably ahead of the times. My own fear was that it would prove too soft for common use, would not stand up, would expand under increase of temperature and would fail to duly contract upon the resumption of normal temperatures. I had no doubts of its electrical merits.

The Postal wire, however, was electrically so far ahead of all expectation, telephonically considered, that it seemed to prove once for all that copper, if mechanically available, was decidedly the proper material to use, and it seemed also evident that if it would stand up alone it would be even more successful as a conductor, if the steel core were dispensed with.

Hard-drawn copper wire was tried after being submitted to the various electrical and mechanical tests, and was not found wanting. In fact, it promised well, and the result was the erection of an experimental line of two wires between New York and Boston, which worked satisfactorily, and with sufficient reliability to encourage its proprietors to build a line of a number of copper wires between New York and Philadelphia.

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The experience gained in building, testing and operating the Boston line has been utilized in the more recent one, which is a model line in many respects.

When we begun to use copper for this purpose, it was not easy to account for the comparative ease with which a line built of that material could be operated. It was attributed by many solely to the low specific resistance of copper, and I recollect instances where I have commented upon this remarkable point and have been met with the remark, "Oh, it is only a question of resistance." But it was obvious that there was some more deep seated reason than the low specific resistance; for, if we take two lines of equal resistance, one built of copper and the other of iron, the copper is invariably by far the easiest one to work.

This was, I confess, for a long time a problem to me, but has recently been wonderfully cleared up, by the masterly researches of Professor David E. Hughes, as detailed in his inaugural address, lately delivered before the Society of Telegraph Engineers and Electricians; with which every electrician interested in the communication of intelligence should familiarize himself.

His experiments showed that the E. M. F. of the extra current, in a solid iron wire is much greater than in a similar copper wire; that ordinary iron wire has, with rapid currents, more than three times the resistance during actual work than that supposed to be its resistance (although with standard iron and ordinary copper such is not the case), and that the extra current in wires furnished with a parallel return wire is much reduced, but much more in copper than in iron. Iron 15 per cent. and in copper 80 per cent.

It is also interesting to learn that the E. M. F. of the extra current in brass wire, compared with copper, is but as 13 to 20. This point may prove useful when a wire, stronger than copper, but of equal size, is at any time required.

These researches are so interesting and valuable that they gratify me nearly as much as though I myself had made them. I am aware that the statements of Prof. Hughes have been severely criticised by Prof. Weber and others, as was to be expected, but I am persuaded that his results will, in the main, be ultimately approved, and his views acquiesced in by the world of science; although it is very probable that some errors of detail may be found in them.

Approaching now advances made in instruments, I may say

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that it is noteworthy that nearly every improvement has been made in the transmitter. There are two good reasons for this. The first being that the receiving telephone came into existence well nigh as sensitive and perfect an instrument as it was possible to make it; and the second, that in view of the noises, made apparent in the receiver on long lines, due to undesired currents, it was manifest that the transmitting power it was that required intensifying, to the end that it might be able to develop currents of sufficient strength to override the disturbing currents, and that if a transmitter of sufficient power could be made, it was even possible to reduce the sensitiveness of the receiver, and thus weaken the disturbing noises by thickening the diaphragm, or by removing it to a greater distance from the magnet. The form of transmitter which has been found most successful is one in which granulated carbon in a loose and free state is employed as the current regulator. When first introduced it consisted simply of a handle, having a disc-shaped cavity cut in its face, the bottom of the cavity being faced with some suitable metal or alloy as copper, silver or brass.

The front of the chamber was closed by a piece of platinum foil, which served as a vibrating diaphragm, and the sides of the chamber were formed of the same non-conducting material as the body of the handle itself. The space between the back and front plates was partly filled with the carbon granulations, and the front plate protected by a mouth-piece. The instrument was then complete, and, though exceedingly simple in construction, worked, and worked well. When in use it was most efficient when held so that the diaphragm presented an angle of about 45 degrees from the vertical position, the upper edge being inclined backwards.

When this instrument was good, it was "very, very good," and like the little girl of the nursery rhyme, when it was bad, it was "horrid."

It had one grave fault, the granulating powder would occasionally pack itself into a mass, and was then anything but as sensitive as it should be; under such circumstances it became a very poor transmitter. The customary remedy for this disease may be indicated by the familiar words of counsel, invariably found upon the apothecaries label, "When taken, to be well shaken," and, when shaken, the sick transmitter would usually resume its duties. But an ounce of prophylactic is better than a pound of

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medicine, and the want was decidedly a transmitter equal to the Hunnings, but which would not pack.

The first step was the adoption of a horizontally mounted diaphragm, the speaking tube of which ended opposite to the lower face, and it was found that when the carbon granules were placed on the upper surface of this plate, the voice vibrations acted upon them with great force, and tended to loosen them if packing had begun. This was not; however, completely satisfactory. It was subsequently ascertained that the back plate should, to obtain the best results, be buried in the mass of carbon which lay on the diaphragm, or should dip into the same in the form of a pendant, and that the resistance of the entire instrument should be reduced as much as possible.

The most noteworthy, embodiment of these principles (or more properly speaking of the first of them) employs for the complementary or back electrode, a metal sieve, which is buried in a mass of granular carbon. In another form the back electrode takes a form something like that of a shade roller pulley, and has a number of holes bored through it in different directions, so that the carbon granulations can freely circulate. In both cases it is found advantageous to plate the electrode with some unoxidizable metal—such as gold; and to form the diaphragm as in the original Hunnings instrument of platinum foil.

One of the circuit wires is united to the diaphragm, the other to the back electrode, and the mass of granulated carbon lies upon the former with the whole or a portion of the latter immersed, or buried in it. These transmitters give admirable results. The tone, volume of sound, and clearness of articulation developed by them is most encouraging, and by their use the range of long-distance telephony has already greatly expanded even on long, single iron wires. The distance that they can be efficiently operated has not even yet been authoritatively ascertained, but, judging from the fact that instruments of the most inferior character can be made to maintain successful conversation between New York and Chicago over a compound wire, we are encouraged to believe that conversation can be easily transmitted over much greater distances than that by availing curselves of the most improved forms of Hunnings's telephone. It is well known that long telephone lines are greatly troubled by the noises manifested in the receiver; these noises being due to magnetic or current induction, leakage from other wires, atmospheric and

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earth currents, and magneto-electric currents induced in them when they are blown about, and thus made to move across the magnetic lines of force of the earth.

It has been found necessary in order to reduce these disturbances to a minimum to adopt an old laboratory expedient, and to provide each line with a wire return as nearly as practicable equidistant with the direct wire from all known sources of disturbance, so that the disturbing currents, proceeding in the same direction on both sides of the circuit, will neutralize one another. But when we take such a double wire we find that it is not easy to preserve its benefits, and at the same time to connect it with a short exchange line at both ends, for, if we take a parallel wire metallic circuit trunk line and connect it with a short subscriber's single wire line by absolute contact, as in drawing A, it is obvious that we have lost the basis of neutralization, and only gained a conductor of lower resistance.

There are two plans from which we may choose. We may run a double wire to each subscriber wishing to use the long line facilities—as in drawing B—in which case the problem is at once solved; for, when we unite the two terminals of the subscriber's short loop line with the two wires of the long trunk line, we have simply extended the said trunk line half a mile or a mile, or whatever distance it may be further.

This plan, however, presents some disadvantages, in that it necessitates a double wire for each subscriber's line, and the concomitant changes in apparatus at the central station; and it is, after all, rather an inordinate expense to incur, when the subscriber may possibly only use the long line once a month.

The alternative plan is to employ repeating translating coils. These are really induction coils of peculiar construction, the two circuits of which are made much nearer each other in the size of wire and resistance than is usual in the ordinary coil.

One of these circuits—that which is composed of the finest wire, and which is wound to the highest resistance—is connected in circuit with the two ends of the long metallic circuit trunk line, while the remaining coil has one terminal, united to the single central station end of the subscriber's line, and the other attached to a ground wire. This arrangement is shown in drawing C, in which one terminal of the local side of the coil is represented as being united with a button switch, by which it may be connected with any desired subscriber's line. The beneficial re-

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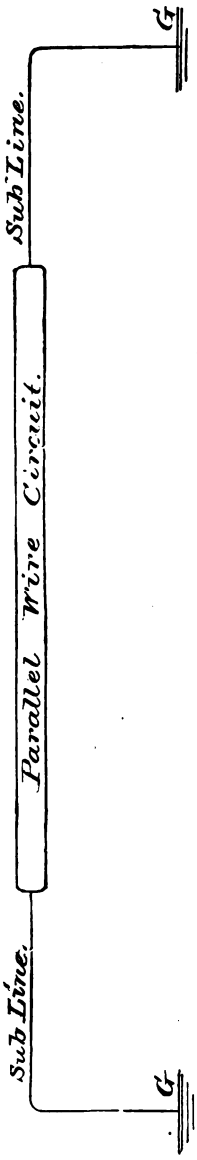

PLATE A.

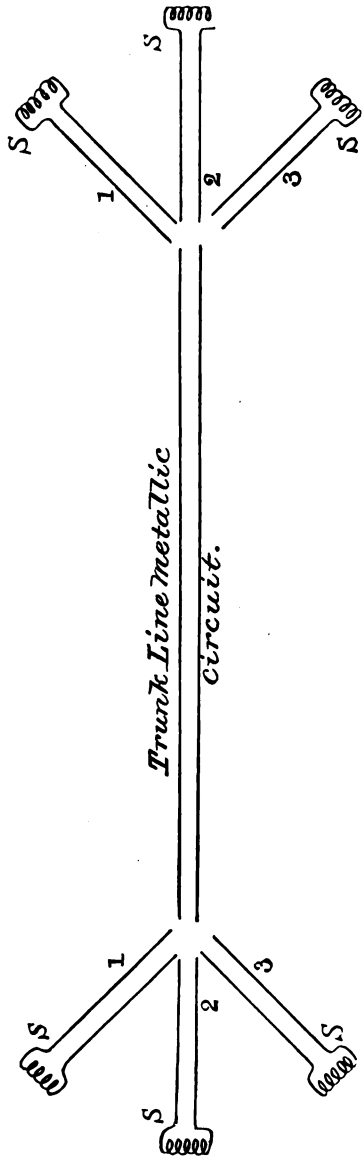

PLATE B.

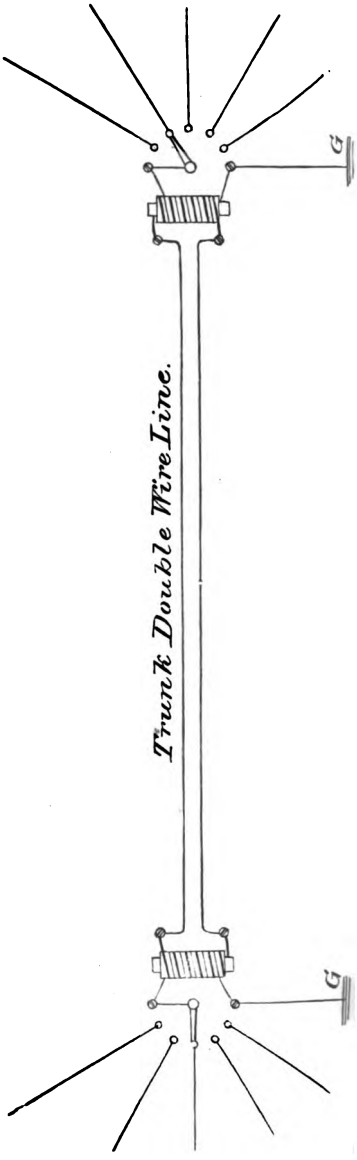

PLATE C.

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sults of the neutralization of the disturbing currents are thus obtained, these being at least minimized by means of the return wire; while the telephonic currents induce currents of like character in the coil which is in circuit with the shorter and local line, thereby reproducing the transmitted speech in the receiving telephones connected therewith.

The reason for making the two circuits of these translating coils so much more nearly equal in character and conductivity than are those of the ordinary induction coil, is that each is in turn the inducing and induced circuit—that is, the conversation is transmitted from the long trunk line to the short subscriber's line, as well as from the short line to the long metallic circuit. Each is, therefore, required to exercise the functions of both primary and secondary coil. I have every reason to believe that the first instance of the use of an induction coil in this capacity was by Mr. Thomas Watson and myself, in September, 1879, immediately after the completion of the two lines between Boston and Lowell.

We used the two lines between the cities as a trunk metallic circuit, and by means of two induction coils, one at each end, two exchange lines were inductively connected with the main line. I operated the ground circuit at Lowell, Mr. Watson engineered the induction coil at the Boston exchange, and Mr. Theo. N. Vail was at his own office in Boston, and talked with me through two induction coils.

The coils we then used were wound with both circuits approximately equal, about 250 ohms each, and were wound together from beginning to end, two wires being wound on the spool at the same time, a mode of construction which, by the way, experience has, I think, demonstrated to be the most satisfactory for inductoria intended for this purpose, and which will probably be adopted.

It is proper to note that we were led to this idea by considering the mode of using the transmitter induction coil, which was even then well known; this use, however, though analogous is not identical, for it must be remembered that in the transmitter coil the iron core is maintained during action in a state of magnetic polarization by the battery currents, whereas the currents, traversing the surrounding circuits of the translating coil, have not sufficient strength to effect such a state in the core, and the induction in these coils is, therefore, almost entirely current induction of one of the coil wires upon the other, the magnetic reactions

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between coil and core being necessarily trifling in character. The induced effects may, however, be intensified by separately magnetizing the core either by a separate battery coil or by a permanent magnet, and I have sometimes done this with advantage.

A third plan whereby the double line may be conveniently connected with any one of a number of short grounded lines, without depriving it of any of its virtue, has been patented by Mr. Geo. H. Bliss.

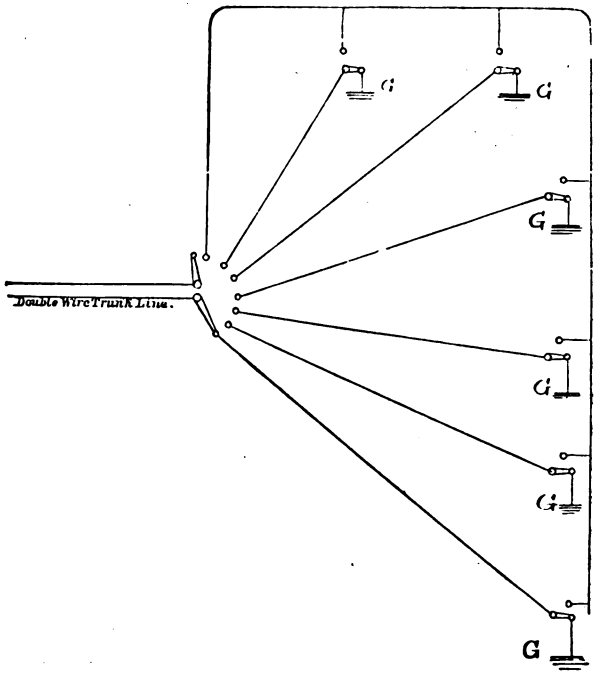

PLATE D.

This is indicated by the drawing D. It consists in extending from the central station an additional line wire, which may branch into as many sub-stations as are intended to use the long double wire trunk line. Each of these sub-stations may be fitted with a button switch which, when turned in one direction, will retain the telephones in their ordinary ground circuit, but which, when turned reversely, will disconnect the subscriber's line from its ordinary earth terminal and unite it with the branch from this extra circuit, thus providing a double, although not a parallel, wire between the central and sub-station, both ends of which may be then united with the two ends of the metallic circuit trunk line.

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One extra wire of somewhat abnormal length is thus enabled to serve in place of a great number. It would be easy to fit the telephone call boxes with a double gravity switch and two separate telephone receivers, one on each side of the bell box, and to so connect these switches with the circuits that it might be invariably understood that when the receiving telephone on one side is taken from its place and used, the line would be used in its normal condition, but that the other telephone, when taken up, would connect itself and the transmitter in the loop circuit. One could then be always used for short line and the other for long line work. I am very favorably impressed with this, and do not believe that it has yet had the trial it deserves.

I am conscious that this paper already is too long. I may not, therefore, on this occasion describe at length the specialties in switching and signaling appliances which have been found necessary, and have consequently developed in the practice of long-line telephony, but hope either to say or listen to something of this branch at some future time.

I have, I think, said enough to prove that long-line telephony is a reality, the *New York Times* on contract obligations to the contrary notwithstanding.

MR. LOCKWOOD: I might perhaps say a little upon another recent advance which has been made. It has been found that a great many telephone companies have not been able, in operating small exchanges, to get satisfactory remuneration, and it has been quite a problem with telephonic electricians to provide some simple system whereby any subscriber could readily connect his own line with any line of the system at pleasure and call up the subscriber himself. I am aware that there are a number of so called automatic exchanges developed especially on paper, but the result of nearly all such schemes is that any person trying to operate them, and any inexperienced person especially, is almost sure to connect himself with some undesirable party. It works all right on paper and sometimes it works right in practice. It is very easy for an electro-magnetic ratchet to make a slip of one tooth, and one tooth makes all the difference in the world when it comes to connecting telephone subscribers. Then when you have connected with the proper line, you must ring up your correspondent and the very act of ringing him up will be very apt to start the machine again and while you are ringing up one you are liable to connect yourself with another. In a small village

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they can stand thirty subscribers at a reasonable price, and one plan is to divide the thirty into six lines of five subscribers each; each line runs to all the subscribers, while its own subscribers are the only ones that have a signal bell connected. For instance if this were number One it might run to station number One, it might have a bell magnet at Two, another one at Three and so all the way through. (Illustrating on the blackboard). In addition to that, each line runs by a loop or branch into every other station. This one in addition to its signal bell will have a spring-jack containing means for introducing telephone instruments, so that he may if he pleases connect his instrument with number Four. The better way is to introduce the instruments right in, instead of having a branch. Here is a card which tells him the signal for every office on every line. If he wants to ring No. 30 or 32 he simply rings that number and he at once gets it on his own line, while the act of hanging his telephone will restore him to his normal condition. There is such a system as this in operation at Leicester, Massachusetts, with the addition of a trunk line which runs to Worcester some six or seven miles, and there is an automatic clock arrangement which can be started up from the office at this end or from any one of these offices and each has an arm running around which successively connects the long trunk line with each one of the other lines and any of the stations on any of the other lines may stop this line at any point they wish. It works very fairly in practice. But the trouble which is developed is not one of operation but is one of original expense; that is that in such a place as Leicester, Massachusetts, where a system like this would be a benefit, the people taking telephones are physicians and large store-keepers and gentlemen of means, but when it comes to the gentlemen of means they are usually straggling a long way off from the people they want to talk to and it doesn't take long to make the expense of running loops and branches equal to the expense it would be to have a competent operator at the central station. I think myself the better way would be to put some fifteen or twenty telephones on one line and if a first class individual signal can be procured, give each one an individual signal, so that any one of the stations could be cut in at pleasure either from a sub-station or from the central. But the individual signals are one of the hard nuts of telephony, and while there are to my certain knowledge one hundred and twenty-five patents on the subject I fail to realize

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that any one of them has gone into successful operation as yet. (Applause.)

THE PRESIDENT: I suppose we can hardly expect that any one here would be able to add a great deal to what Mr. Lockwood has said on this subject which he is perhaps more familiar with than any other person in the country, but there may be some who would like further information about it, or who desire to ask questions and perhaps make some remarks and we would be very glad to hear from them.

THE SECRETARY: I noticed the other day an extract from a Waterbury paper, saying that there was a movement among the manufacturers in the Naugatuck Valley, to dispense with their warehouses in New York and do the business at the shops. It occurred to me at that time that possibly the introduction of this long-distance telephony might have something to do with it, as I understand that some of those firms have made arrangements with a "long-distance" line between New York and Boston, to do their business during a period of two half-hours a day or something of the kind. I would like to inquire whether this is the case and whether they have got it to such perfection as to do their business and dispense with their warehouses in New York. Holmes, Booth and Haydens, I believe is one of the firms.

MR. SHELBOURNE: In answering the question, so far as I am able, of Mr. Pope, I would say that there has been in this city for a year or two, a company that is doing long distance talking between Connecticut towns and New York city, and they have an arrangement of their wires by which they connect with the principal warehouses here—connect their warehouses with the factories. For instance, they give Holmes Booth and Haydens, or the Ansonia Brass and Copper Company, a certain interval of the day in which they can have the wires exclusively for their factories and they connect them on their iron circuits. They have, I believe, one copper circuit. In favorable weather and under favorable conditions they also use some of the iron circuits—metallic circuits.

Now, of course, that is a mere question of commercial advantage. If they can dispense with their warehouses here and do their business direct with their customers through these telephone wires, that is a question for them to determine.

In connection with this service in Connecticut, an induction coil of my invention, of peculiar construction, has been in use for

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some months, and that brings me to that branch of the subject that was quite elaborated by Mr. Lockwood. He spoke of the induction of parallel wires in such an induction repeater. That certainly is the case under the conditions in which he represented the matter. Some couple of years ago I conceived this way of overcoming that difficulty. I employed a core made of small soft iron wires bunched, about two and a half inches long and about a half inch in diameter. Of course when we come to the high induced current that we find upon the line in telephoning, we know that it has very little effect, because the quantity of current is not there, and the intensity does not produce that effect in the core which we might expect from a primary current in the same wire, and therefore the effect is principally due to current induction between the parallel wires. I am aware of Mr. Lockwood's efforts in that direction, and I am aware also of his use of wires for the induction repeater, one of which is somewhat larger than the other, making what is called the primary, and having in parallel circuit with it, around the core, a smaller wire, which, perhaps, may be called the secondary; but the winding of the large wire stops short of the end, and the smaller wire forms what is called an additional secondary over the large wire. Now I find that the best results, I think the best possible results —I may be mistaken in that, because we do not know what is possible in these things—are produced by having the wires exactly of the same size, so that the induction repeater is made entirely reciprocal, and to get the best possible effect out of the cores, instead of having one core, I have the cores in pairs, and these two wires are wound entirely as one, parallel of course, with the ordinary silk-covered insulation, to a very moderate extent around each of the cores, so that all the current you do get into one of the wires, which we will call, perhaps, for the purpose of illustration, the primary or the induction-giving wire, produces its best effect with a very small thickness around the core. Then the cores are associated with each other, and the spools containing these parallel wires are placed on ends, so that the cores will have the north and south poles adjacent. Then the wires being connected with the posts of the instrument, the two spools, if there is only one pair, are associated with each other, the one with the north pole adjacent to the south pole of the other, and the two are enclosed in a soft iron case or box, but before that is done a plate is put upon the base of the instrument, a soft iron plate, but

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which is separated from metallic contact with the cores, and in putting the cover upon the oval box, the covers forms a soft iron plate at the top; the whole is fastened together by a brass rod, screwed down through the base of the instrument. Such an instrument as that has been used for months, as I said, in connecting with those Connecticut towns, and working between those towns and the subscribers in New York, such as the Ansonia Brass and Copper Company. It has also been used experimentally between New York and Boston. Of course the lines of force that emanate from the cores produced by the induction-giving circuit are, in such an instrument as that, condensed, and they are made to cut relatively the wires around both the cores. Now the question arose in connection with this instrument that, whether using it in connection with a metallic circuit between exchanges—Mr. Lockwood has very happily explained the advantage of a metallic circuit in avoiding induction, and also the necessity of having the wires associated, so that their induction-giving and induction-receiving effects would be from the same line and distance in space—such an instrument put in the exchanges at either end of a metallic circuit thus arranged, would repeat the voice from a subscriber inductively at one exchange, however distant, within working limits, to a subscriber connected inductively with the other exchange. But in presenting and testing this instrument in this city connected between metallic circuits, (although they were not twisted together) and ground circuits at either end, the question was suggested by the vice-president of the Metropolitan Telephone Company, whether it were possible to ring up the subscribers inductively through such an instrument as that. Well, I said that was a question I could not answer. So in connection with the electrician of the Commercial Cable Company, although we could not get the battery which was in use with the pole changers in the exchanges because they were continually in use, we put up the same kind and amount of battery used upon the single trunk line circuits here in ringing up subscribers at either end. That is, we found in one exchange two gravity cells for quantity and ten for series, making twenty cells, and without the advant age of the pole-changers and through the ordinary magneto, we found that this induction instrument would operate perfectly, that is, we could ring up the subscribers from a metallic circuit with the same effect as we can now through a single trunk line.

In regard to the two limbs of the metallic circuit, not giving

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induction from the same distance—the experience of the countryman referred to by Mr. Lockwood is not altogether unique, for I could mention here some persons who are considered pretty well up in electricity, who started a line in Ohio in the early experience of telephony and that same question arose. In connecting Cincinnati with some other towns they did the same thing, they got up a round detour circuit, and the question was, how it was they did not avoid induction. Of course the thing is explainable very easily. You may run a metallic circuit around in a circle and you may get more induction, as Mr. Lockwood has said, than if you had a ground circuit.

THE PRESIDENT: There was one point I did not quite understand from Mr. Lockwood's paper. I would like to ask whether the variable resistance of the transmitter is in the same circuit with the primary of the repeating coil, or whether it works on an induction coil in the transmitter as usual, and that coil works on the repeating coil, so that there are three induction coils in the circuit.

MR. LOCKWOOD: The transmitter is fitted up with its own low resistance primary coil, and the secondary current repeats itself through the translator. There is little loss through the translation except at first. There is certainly a small amount of loss with this translation, but nevertheless the system will be practicable for commercial use. I can corroborate what Mr. Shelbourne says—it is very easy to ring a bell even through the two induction coils; even by simply making a break in the original battery circuits the impulse is reversed.

MR. SHELBOURNE: Our experiment was successful without the pole-changer, because we did not avail ourselves of that.

THE PRESIDENT: I might remark in reference to this question of the loss in conversion in the induction coils, that some experiments that I have recently witnessed in another branch of electrical work, which it would not be proper for me to give the particulars of at present, showed that with a properly constructed induction coil the loss in conversion is exceedingly small, so that I think there is good reason to suppose that by further researches some particular form of induction coil or mode of construction may be found in which this loss by conversion may become very trifling. Probably it will not be sufficient to be noticeable unless there are quite a number of transformations—quite a series of them. I should think from what I have observed in this matter that it is probable that the loss in three

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conversions could be brought down within ten or fifteen per cent of the total effect.

MR. JONES: It would hardly be in keeping with the intelligence of the members to make any reflection upon the ability with which Mr. Lockwood has dealt with this subject, but of course after a good hearty dinner we want a little charlotte-russe, and I suppose it is the duty of each one of us to contribute to this subject while it is under our consideration. I happened to use the two first instruments that Mr. Gardiner G. Hubbard took to the west, and made the first experiments on them I believe early in 1877, and we talked readily two hundred and forty miles, and a distance of twenty miles regularly every Sunday. We put them all in circuit in a room, having a piano and a flute and an accordion, and different instruments, and had them all going at once, and somebody talking at the other end, and we could get the whole menagerie right there. We got up a musical telephone at Cincinnati, which you know is about three hundred miles off, and we were able to produce these musical sounds in one of these box relays to perfection. The Governor and Secretary of State, and all the electricians round about for miles, came around and heard it. We had a little cigar box with a slit in the top, into which they dropped a nickel, which started it; and I believe we made enough money to pay the expense of the scheme. We called up the chief operator and asked him to connect Cincinnati and start the musical telephone. By means of a button under the counter we set it going. We had a little music box inside. (Laughter.) As to the other scheme they had out there, I don't know how well it worked. I know I was in Chicago at the time and had charge of the office, and if any such conversation went through the office it was when I was sound asleep.

In regard to working circuits with a great many instruments in, we tried in the early days in Chicago to consolidate them into one line, and by putting a little coil of resistance around the electro magnet or receiving instrument, we rendered it less opaque to the voice vibrations than if they had travelled all around the convolutions. Another plan we had was to split the relay. I think that is all I can contribute to the subject.

THE PRESIDENT: If there are no further remarks to be made, we will proceed with the next paper, which is on the subject of "The Patent Office and Patent Office Practice," by Mr. Fowler, formerly one of the examiners.

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THE PATENT OFFICE AND PATENT OFFICE PRACTICE.

BY A. C. FOWLER.

At the request of the council of the Institute, the following paper has been prepared.

At first I was at a loss to know why I had been called upon to write something on this subject, thinking that this would be assigned to some older member of this society, who had been longer in practice before the patent office; but the honorable secretary informed me that I had been called upon because of my experience as an examiner in the patent office, and especially in the electrical division, and could handle the subject from the standpoint of an examiner as well now as an attorney (although one of several months standing only), and could express myself freely, inasmuch as I had now severed my connection with the patent office.

It was my intention a month ago, upon receiving the invitation, to give the subject much thought and attention; to compile statistics and to review decisions at some length; but I regret to say that the pressure of business has compelled me to abandon such an undertaking, and to content myself with making some observations on this subject which I trust will prove of interest.

One of the first things desirable, indeed we may say imperative about any practice in whatever jurisdiction, whether it be in equity, at common law, or before the patent office, is stability. I have several times heard lawyers remark that they could get along all right in the courts, but that the patent office was too much for them. It is often remarked that courts adhere too much to old forms and to old practice. The advantage of this is upon a little reflection readily seen; you always know where you stand; you know that the practice to-morrow will be the same as to-day. You are not told in a decision to-day that process and apparatus can be claimed in the same case, and by another decision to-morrow that this cannot be done. Under a decision to-day you are not given all information necessary to go into interference with a pending application if you choose, and by a decision rendered another

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year, all information whatever concerning an interfering case is withheld from you. Nor would you have to submit to such a thing as a strict interpretation of the statutes and rules regarding interference one year and loose interpretation another year. Nor would an oath that was formal one year be declared informal the next. Nor would you have to limit your claims to "*means as described*" and by the practice one month, and by the practice a few months later find that you are not required to so limit them. Nor would you be harassed and annoyed by startling innovations every month or so by an issue or draftsmans' division. By such a practice you never know where you are, nor whether you will be in the same predicament to-morrow that you are to-day.

So you see there is some advantage in having a practice and a law like the old unwritten common law and practice that has been handed down to us by England, and extends back to a time whereof the memory of man runs not to the contrary.

Under such a practice an attorney always has the law and the practice within easy grasp. He is always competent to advise his client. The practice is uniform and unvarying to a great extent. The practice of the patent office on the other hand is irregular and unstable. I say these things not to cast any reflection upon the officers of that bureau, nor to disparage the work done by this office, for I have the highest regard for them and for the arduous duty performed by them; nor am I unmindful of the serious disadvantages under which they labor. Neither would I be understood as not favoring progress and the removal of bad and unjust rules and laws in regard to patents, and the improving of the patent office practice by establishing new rules and precedents and by rescinding and overruling bad ones; at the same time I cannot help but think that the patent office practice needs reforming and that more stability of practice would be one of the greatest steps towards this.

There is another thing in which the patent office appears to excel, and that is—the facility with which one tribunal or examiner overrules another. There is, I believe, nobody having judicial functions in which opinions and decisions are so often reversed and overruled—so little regard for precedents. The want of concurrent decisions in the patent office appears to be remarkable. This tendency to reverse is so marked that some of its officers have been known to sometimes overrule the U. S. Supreme Court. It may be that this is to be looked for where

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there are so many questions of fact, as well as so many questions of law and practice, with so many tribunals to take cognizance of the facts, interpret the law and decisions, and administer the remedy.

The want of stability of the patent office practice above referred to, it appears, results from several causes:

FIRST. There are so many independent tribunals or heads to interpret the law and decisions.

SECOND. Some of those who are called upon to interpret the law and to apply the decisions fail to discriminate legally, but apply decisions alike to all states of fact, whether a different state of facts exist or not. To act judicially, and to apply decisions and decide questions involving legal points, one must, of course, be legally equipped to some extent and possess a certain legal inclination, and be capable of making nice distinctions, so as not to apply decisions and rules indiscriminately and misapply references. So that an examiner should be something in a judicial way as well as a man versed in the arts and sciences. Some of them are undoubtedly too narrow and illiberal, and should broaden their ideas a little. Some of them seem to act as if they were placed in their positions by the government not to grant patents, but to antagonize and harass inventors. These examiners act upon the principle, which is contrary to the legal maxim, that it is better to let ninety and nine meritorious case suffer than to let one unmeritorious one pass. The question with these examiners is not *how to do* but *how* NOT *to do*. They forget that they are placed where they are by the government to facilitate and expedite matters—not to impede and obstruct—and that they are there to grant patents, rather than not to grant them. Of course a case should have a rigid examination and not a lax one—for the better, the more thorough the examination, the better for all parties concerned.

THIRD. Many of those in responsible positions have not had sufficient time to become versed either in the patent law, the practice or the arts. This results from the fact that many resign to go into practice in the various arts in which they become proficient in the patent office, owing to the fact that the government does not pay them enough to retain them, and they seek a field wherein they can make more. It is rare that a commissioner remains at the head of this department over a few years. He is called upon to act judicially as well as ministerially, but does not

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remain long enough to become well acquainted with the law or practice. The salary of this officer should certainly be increased considerably over $5,000, his present salary. He has so much to do of an executive nature that he has not sufficient time for judicial acts. The latter should no doubt be taken from him by statute, and be made to devolve upon some other person or tribunal appointed for this purpose. By this means the practice of the patent office would be rendered more stable. All the examiners in the office should then be required to adopt the rulings and decisions rendered by this tribunal, instead of interpolating their own ideas and making their own precedents.

Politics, which is generally in the interest of a few and not of the many, also operates against the efficiency of the patent office. I know of no bureau under the government, however, that is freer from the plague of politics than this one; yet politics does militate against it in more ways than one.

Of recent years examinations for promotion have been abolished, but I am happy to say within the last month they have been revived. While competitive examinations are not an absolute test of a man's capability and efficiency, they have proved to be the best system for the patent office. It was urged during the existence of the competitive examinations for promotion that the examiners spent much of their time studying up, to the detriment of the service. Since competitive examinations have been abolished they have wasted more time trying to get promoted. By the first system what the man gained by studying up was gained by the office, but by the scramble-for-promotion system the man gained nothing that benefited the office; in fact the office lost, for this system of promotion which did not investigate the merits of men, could not be a test of fitness. The patent office, however, has always held competitive examinations for appointment to the examining corps, and of recent years graduates of scientific schools and scientific me generally have been notified of such examinations in order to give them a chance to compete. By this system the examining corps has been recruited from men who are well fitted to fill these positions.

Many, however, have been given positions in the examining corps within several years past, contrary to precedents and without examination. The method of doing this has been to give the person a position as laborer in the department, or some other minor position, requiring no examination for appointment, and

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inasmuch as there is no rule or law governing promotions, to promote the aforesaid person in a few months to an assistant examiner. So that where many of scientific attainments have been turned away because not able to pass the rigorous examinations for appointment, these favored few have crept in.

The question is: How can these evils be eradicated; how can the system be improved and how can the rapidly changing personnel of the examining corps be made more permanent. The last can only be done by raising the salaries of the examiners. A principal examiner gets but $2,400, and his first assistant but $1,800, and so on down. How can this office hope to keep men who are expected to know the law and to be versed in the arts and sciences at such salaries? These matters can only be reached by Congress and Congress can only be reached by votes. Those of you who are interested in these and kindred questions concerning the patent office and the patent practice, as well as all manufacturers who are interested in patents, should demand of your representatives and senators that these evils be remedied. Make it a question of votes and you will accomplish something. The average official life of an examiner in the electrical division is rarely over three years, and as soon as he becomes skilled in this art he seeks a more remunerative occupation. This division is subject to more changes by reason of resignations than any other.

By carefully conducted but not too rigorous competitive examinations upon technological and scientific subjects, and the exercise of good judgment, for admission to the corps, and an examination upon these same topics and the law and practice for promotion, only those will reach responsible positions who are qualified to answer all requirements, and must therefore give satisfaction.

The patent office ever since its establishment has been, as you all know, a self-supporting institution. Being so it is difficult to understand why it is treated so niggardly by Congress. The reason is, because you have not made it a question of votes. It is in fact more than a self-supporting institution. Out of the patent fund has been built one of the largest and most imposing buildings in Washington ostensibly for the patent office; but this office is permitted only to occupy a small portion of this building, the major portion of it being occupied by the interior department and its other bureaus, which have never paid anything to the patent office or the patent fund for the use of

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this building. This office occupies the most undesirable portion of the building, and is hampered in its work by being overcrowded and the health of its employes seriously endangered thereby. The patent office owning all the patent office building should have as much room as it needs in this building, and Congress ought to see to it that the bureaus of the interior department which are located in it and take up the room needed by the patent office, be required to move into quarters of their own, provided for this purpose.

Why should inventors be taxed for the benefit of the other bureaus of the interior department? Why should there be a surplus of receipts over expenditures each year in this office? Should not the money received by the government for a given purpose be expended for that purpose? Should not all the money received for the patent bureau be expended for this bureau and for the good of the service and not diverted from its purpose? There is only one answer to these questions, and the government acts in bad faith when it receives money for one purpose and expends it for another. You are aware, perhaps, that the electrical division has no electrical appliances to speak of, with which to test apparatus. They have asked and asked again for a laboratory, but in vain. Every division in the office needs men, needs facilities, needs everything.

The patent office is said to have to its credit, in the treasury of the United States, about $3,000,000. It has been proposed by Congress to appropriate this surplus for educational purposes. While it could not be diverted to a better purpose there is no reason why all of this fund should be used for the above purpose. I am told that some years ago, an assistant commissioner investigated this question of the surplus of the patent office, a d found that as a matter of fact, if due allowance had be n made in years gone by for printing done for this office by the government printing office at public expense, that this would about offset the surplus of three millions. This money of course had to be appropriated by Congress for the printing office, and in this way Congress was really making appropriations for the patent office through the government printing office. In recent years the cost of all the printing done for the patent office by the printing office has been deducted from the patent office receipts, but even now there is a large surplus of receipts over expenditures every year, which in some years has amounted to several hundreds of

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thousands of dollars. So you see that the patent office formerly was about self-supporting only, but of recent years is more than self-supporting. Now if the interior department had allowed the patent office anything for rent of its building, the patent office would nevertheless have a large surplus to its credit in the treasury; but if all the money now received be expended for the patent office, so as to make the expenditures equal to the receipts, you should feel satisfied, as the service would by this means be very much improved.

Either this should be done or the patent fees should be reduced, for by the present system the government is imposing a tax on inventors, which, I take it, was never intended to be done. The idea of taxing patents is a foreign one to us. It is the course pursued by foreign countries, and tends to check invention and deter inventors from taking out patents. This is attested by the growth of inventions and patent interests in this country, which exceed by far those of any other nation in the world. It is not that American inventors are more ingenious than those of other countries, but because the inventors are not taxed as they are in other countries. A tax upon the patentee was never intended by law. A patent is in no sense a monopoly.

The fees for patents in this country are surely small enough, and every inventor, I think, would be glad to have them remain as they are, if all the fees were paid out for the good of the service. It is the salaries of the examiners which should be increased.

Now then, you say, suppose the American system remains as it is, what is going to become of it? The chances are that it will go along as it is, unless some steps be taken by you and all of us to prevent it. Each day the examinations in the patent office are becoming more a matter of form and less a matter upon the merits. This cannot be helped with the amount of work on hand and the force to do it. Every day our patent system is becoming more like the English system and the systems in other foreign countries, where no examination on the merits is made, and where a patent gives you no *prima facie* right to the thing patented. The distinctive features of our system are rapidly passing away, and it will not be long before the patent office examinations will be formal only, and our patents will have to be sustained in the courts before they are worth anything. Every day less and less importance is attached to a patent in this country. This rapid

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approach of the American system to the English and other systems will go on until the patent office gets to be but a mere registration office.

The tendency of this will be to increase the business of solicitors and patent lawyers. The former will be called upon under this system to make the examination on the merits, which was formerly done by the office, and draw up the papers in accordance therewith, and the patent lawyers will have more suits to bring; so that this system will bring advantages to some but will be disadvantageous to others. On the other hand, capitalists will be slow to take hold of or buy up inventions, and thus the patent interest will suffer to a marked extent. For one, I shall be very sorry to see such a change.

Regarding the value of caveats, it may be said that they are practically of no use. I generally advise those who ask my opinion, notwithstanding it is prejudicial to business, not to apply for a caveat. A sketch of an invention, with perhaps a short description and a witness or two, in the hands of the inventor will afford as much protection as a caveat. As a matter of fact, but little attention is paid to caveats by the office, and they are often overlooked. I only remember having notified one caveator to complete his invention during my experience of over five years in the examining corps, and then after he had completed his invention within the three months allowed, it was totally different from the other party's. This is about the only instance in which the patent office takes your money and does not give you an equivalent. It seems that the law relating to caveats could very properly be repealed. They cannot in any way prevent an interference, and inasmuch as you can go into interference with a case just as well after it has been patented, you can see that a duly witnessed sketch establishes your date just as effectively as a caveat, and does not cost ten dollars.

It is encouraging to note that reissues in the courts and in the patent office are beginning to be looked upon with more favor. The decisions in the Giant Powder Company *vs.* The Vigorit Power Company, James *vs.* Campbell, Miller *vs.* Brass Company and others, went to about as great an extreme in one direction as did the patent office formerly in the other in granting reissues. There is, no doubt, a middle ground upon which they can safely rest. The question as to the advisability of reissuing is one requiring much thought, and can never be absolutely free from

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doubt. It does not appear to depend solely upon the time elapsing between the discovery of the mistake and the time the reissue is applied for. Of course laches is taken into consideration, but the question depends somewhat upon whether intervening rights have accrued in the meantime. Where none have accrued, and the time is not unreasonable, the question is easily settled.

The question of interference is a perplexing one to many, but the proposition is a simple one. The one first to conceive is entitled to the patent, *provided* he is using reasonable diligence to perfect his invention. It of course makes no difference whether another perfects the invention first, as long as you are the first to conceive and are using reasonable diligence. Neither does it, of course, make any difference whether the other party has obtained a patent, for it is invalid if you were the first to conceive and have been diligent. Whether the old system of interferences is better than the present system is a question upon which a great deal can be said on both sides. Parties now, as you well know, are not placed in interference until they claim the same subject-matter. Previously when one party made a claim that the other one could make, but who only showed and described the subject-matter, the former was notified of the other's claim, and given a certain time within which to amend his claims if he chose. By the system now in vogue many cases go to patent which ought, as a matter of fact, to go into interference, instead of giving a patent on substantially the same thing to each party because they did not claim exactly the same subject-matter. So you see by this system a great many patents are now issued which show and describe the same subject-matter, and thus a confusion arises, and this casts odium upon patents. By the old system a bad attorney, who did not know how, or take pains to claim the invention properly, got the benefit of a good attorney's work; besides, people are supposed to know what they have invented, and they are at liberty to claim what they wish, and this is their own lookout. The present system was inaugurated a few years ago, at a time when the interference division was overrun with interferences, and this course, it is said, was adopted to relieve this division. Since its adoption the number of interferences has decreased materially, and cases are often now held by the office for months waiting for parties to claim the same subject-matter. The office, however, is now very liberal in construing the rules relating to interferences in view of certain decisions, and claims under the new system are now placed

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in interference whenever they can be construed to cover the same subject-matter. But even under this practice many cases go to patent which should in reality be placed in interference. Of the two systems, therefore, it seems that the old system is preferable.

The decisions in *ex parte* Blythe, which held that process and machine could not be claimed in one and the same case, as you may be aware, has been overruled. This indeed is a step in the right direction; for this decision brought about some absurd results. The test in these cases as to whether a process and product or machine can be joined in one application is: whether they are inseparable, that is to say, if the product can only be produced by the process or method, and no other process or method is known by which the product can be produced, then they can be joined in the same case. So too, if the process or method is inseparable from the machine and the working of the latter carries out the former, and no other means are known by which the method could be effected, they can be allowed in the same application. Of course the method must be something more than the mere necessary operation of the machine. So where a machine produces a product and no other machine or method is known by which the article can be produced, it can be claimed in one and the same case with the machine. So too where the method, machine and product are inseparable as pointed out, they can be joined in the same case.

Just what a method is, is difficult to say. The term is used as synonymous with process, but the word "method" refers generally to mechanical processes or operations. A method has never been clearly and fully defined, and whether a claim is for a method or for the operation of a machine, or whether in fact it be a method at all, are matters upon which there is much diversity of opinion. Some say method claims should be wholly independent of any means, and not limited by the means whereby the method is accomplished, but this must be received with some allowance; for it is well-nigh impossible to draw a method claim without specifying some means. Some say on the other hand, that a method claim cannot cover anything that is automatic. That as soon as you introduce the word "automatic," in a method claim, that it becomes in whole or in part a claim for the operation of a machine; for they hold that whatever is automatic depends upon the machine itself, and does not depend for its operation upon the exercise of thought or volition, and hence cannot be said to be

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within the term "art" used in the statute. It is difficult to say whether this is to be accepted, and in some cases it is not seen how it can be received. These method claims are very much in vogue just now, and as electricity is known and defined by its functions only, and as it is difficult to define sometimes an electrical invention in any other way than by its functions, the method claim is very common in the electrical division. These claims certainly come nearer covering principles of operation and functions than any others that are allowed. Some also go so far as to say that there can be no such thing as a joint invention, and they hold the idea of joint inventorship, as a matter of fact, an absurdity.

To tell what the office considers a functional claim is difficult, sometimes it's one thing—sometimes another. It is granted, of course, that where elements of the combination are specified, and their functions added, that this does not render the claim functional; but where there are all functions and no means, or where a result is specified without stating any means, or sufficient means, the claim may be said to be functional, although the latter is said sometimes to be a claim for a result. I think it will be admitted that the nearer you come to claiming the functions or the principle of operation of your invention, the better you are protected. In fact, to claim a thing functionally is the easiest and clearest way of defining an invention, but since this is not permissible, one must content himself by protecting his invention as best he can. Under the German system it is deemed advisable to make the claims few and functional, and, as you well know, they hold very strict examinations there, and concerning questions of patentability and matters of form are very particular.

How to claim an invention is a question. The claims as you know are the vital part of a patent. You are well aware if a man describes and shows a dynamo machine in his patent, but only claims the commutator, that the patent is good only for the commutator, so you see a man may invent, describe and show a very good invention but claim a very poor one. Whether a few claims will do or whether many would be better is a question. It is always safe, however, to err on the right side, and it seems that claims ought to be drawn somewhat like the counts to an indictment; so that where you fail as to one, you may prevail as to another. It seems to be a good plan to draw your claims as broad as possible, and then to put in claims a little narrower and

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so on down, until you reach the exact construction of your apparatus, so that should it happen that some of your claims are too broad or do not interfere with the claims of a pending application even, you can rely or fall back on the remaining ones. The graduating of claims in this way seems almost a necessity. It is not meant by this that claims should be unnecessarily multiplied or too numerous, yet redundancy, you know, does not vitiate.

There is another thing, and that is, you must not accept every rejection of the patent office as a good one. The spirit of acquiescence must not be too strongly marked in you, else you will not get what you deserve. On the other hand, you must not waste time unnecessarily antagonizing examiners and wrangling over small and unimportant points. You must fight, but you must fight for something.

The examiners of the patent office are often censured by patentees and assignees of unexpired patents for granting certain patents. These persons are continually finding fault because subsequent patents have been granted which conflict with their patents. These parties make a mistake that is often made, that is, they do not distinguish between patentability and infringement. The patent office deals with questions of patentability only. It is not the duty of examiners to pass upon the question as to whether a subsequent patent is tributary to your prior patent, or whether it is an infringement, or whether a claim is broad enough to include a subsequent one. They decide whether there are any substantial differences and whether these differences are new and useful, not whether the subsequent patentee has to make use of your invention before he can use his own embodying these differences. A thing, of course, may be patentable, and yet an infringement. The courts only deal with both of these questions.

The limiting of patents to expire with the expiration of the first expiring foreign patent previously granted is a section of the law that still remains unrep aled, although much has been written and said on this subject. There is no reason why this limitation should exist, and it should therefore be removed.

The question often arises when is the best time to sell an invention or patent right? This time is, I think, while it is pending in the office, after the case has been allowed, and when it is yet in the issue. An invention at this time

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seems to command more respect and a better price than at any other time. It seems at this time to be surrounded by a halo as it were, and as soon as it becomes public by reason of patenting, it seems to lose in value and respect. Before the case is allowed there is doubt about its being allowed, but when it is allowed, you know that as soon as you pay your twenty dollars you can have a patent. At this time also it is best to apply for your foreign patents, and you have six months after this in which to do it, as you know.

One is often in doubt whether it is safe to exhibit an invention before patenting. Experience in the office and in the interference division has taught me that interferences between independent and original inventors are rare They are generally between employer and employé, or between men working in the same shop, or between those who have in some way seen or got an inkling of another's invention. There is of course some risk assumed in exhibiting an invention while in the issue, but not a great deal; here you have the matter to some extent within your own control, for as soon as you find out that some other party is inventing in your line, you can pay your final fee and your application will go to patent. Before the case reaches the issue you of course do not know whether you can get it through, or how long it will take you to do so, and it is therefore not safe to show the invention at this time except to reliable parties. Interferences, I suppose, are as frequent, if not more frequent, in the electrical division than in any other. Inventors in this line seem to exhaust one field and then take up another. Each watches what the other is doing and keeps pace with the literature on the subject, which often directs them in the same channel.

Not more than ten years ago the electrical division was a small portion of the division of measuring of philosophical instruments. To-day it is about twice as large as almost any other division, employing in all nine examiners: one on dynamos, motors and regulators, one on locomotion, telephone systems and calls, one on telephones, one on telegraphs, another on arc lights, another on incandescent lamps and systems, still another on batteries (primary and secondary) and alarms, and two on miscellaneous classes. Until within not many years ago telegraphy in one form or another constituted almost the whole class of electricity. The number of inventions in this latter class has been steady from the first and holds its own to-day. The applications for arc lamps were at one

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time very numerous, but have now fallen off. Secondary batteries with which the office was at one time flooded have now fallen off to almost nothing. Invention in dynamos, regulators, telephones and incandescent lamps is steady; while motors and locomotion appear to exceed all others just now. The various methods of signaling with electricity, including clocks, are quite numerous. There have been about ten thousand patents granted in the electrical art already, and the outlook for electrical invention seems very bright still—brighter than ever before.

The question of modifications (which was discussed at the last meeting of this society) is easier of solution than some others. A man of course cannot wait until he invents all the modifications or species under his genus, if he did some one else might get a patent while he was doing so. If you secure a good broad generic claim and are the first one to occupy the field why will not this answer all practical purposes as near as possible? If any one else invents a modification of your apparatus it is, of course, tributary and subsidiary to your patent. His modification is covered by your patent. Now, of course, it would be well for a man to suggest all the modifications possible, but there is sometimes no limit to modifications. An inventor ought undoubtedly to take out subsequent patents on all the good and substantial modifications he afterwards invents so as to fully occupy the field, even if these other inventions be tributary to his invention, as this is sometimes a question of doubt, though not often, and sometimes you can be very much annoyed by patented modifications in adverse hands. It is often doubtful whether one thing *is* a modification of another, and very often you are called on by the patent office to divide out subject-matter which *you* think is a modification. Of course, if the latter operates on a different principle from the other subject-matter, and a generic claim cannot be secured which covers both or all, then they are not modifications of one another, but are separate and independent inventions. It is not an easy matter to determine these questions sometimes.

What can be included in one application is also difficult to say. If several things have a special community of operation, that is, if one is specially adapted to be used with another, and cannot be used generally with other devices, then they can be joined in one application. In these latter cases also, the patent office often calls for a division.

It seems best, in order to cover modifications as much as

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possible, to put in your specification something like the following That you do not limit yourself to the apparatus shown, as the apparatus may be varied and made in various forms without departing from the spirit and scope of your invention, and that you reserve the right to make such changes in practice as fall within these limits.

The advisability of taking an appeal is sometimes under consideration. Examiners are, as a rule, quite fair, except in some instances. Each has his peculiarities. It is of the greatest importance to understand your examiner in prosecuting a case. What will be allowed by one will not be allowed by another. It amounts to a study of men as well as to a study of practice of your case. An appeal is scarcely warranted unless you have a *bona fide* grievance and are being seriously wronged. It might have been adverted to in the previous remarks, that there does not seem to be enough intercourse and exchange of references between different divisions of the office. Each division regards itself somewhat in the light of an independent sovereignty, exercising an independent and exclusive jurisdiction, and claims are sometimes allowed by one division which could readily be anticipated in another.

Among the needs of the patent office might have been mentioned the want of some means by which to investigate the question of public use. This office has no means whatever of getting at this question, except in interfering cases. This is an extremely perplexing question to handle, nevertheless it would seem that this office should have some means whereby this matter can be looked into. The patent office is often censured for granting patents for old things—things that have been long in public use—yet if these things are not among the records in the patent office, and are not within the knowledge of an employé, there is no other course to be pursued—a patent must be granted. An application for a patent under the law and practice is an *ex parte* proceeding, and no notice is taken of affidavits filed in opposition to the grant. The American system might with advantage adopt something like the English system, wherein any interested party is allowed to oppose the grant of a patent upon good and sufficient grounds, all applications for patents being duly advertised before hand.

It is of the utmost importance to have your invention illustrated by first-class drawings, which show clearly every feature and

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modification of your invention. This is rendered imperative, for the reason that examinations by the office of the antecedent state of the art are made from the drawings almost entirely. Specifications are rarely consulted, except when there is doubt about what the drawings show. So that where you get a patent and do not show clearly and unmistakably every feature, some subsequent party may possibly get a patent for what you have so described. Of course you are aware that every modification described, unless it be an obvious one, must be illustrated in the drawings. So that it does not do to suggest a modification unless you illustrate it.

Before closing, I cannot refrain from paying a high tribute to the examiners of the patent office. I would not have you think, from any of the above remarks, that I am unfriendly to them or have had cause to say aught against them, for my relations with them, both in the office and out of it, have always been of the most friendly and cordial nature. I have often expressed the views contained herein while a member of the corps. Their lot is not altogether a happy one. You have no idea, I am sure, of the amount of bad grammar they are inflicted with, and the quantity of bad spelling, and the ignorance they have to contend with. The idea has been suggested that specifications should be printed as they are written, without official corrections, so as to show the public just how skilled some inventors and their attorneys are. The idea is not a bad one. You would scarcely recognize some specifications before and after they have received an official dressing.

You know, of course, that the patent office acts only on what is put before it. It does not suggest claims and the like, or supply defects, except when they are matters of form, and rarely then. Examiners are therefore very often blamed for the ignorance and mistakes of others. The patent office undoubtedly ought to have some requirements for admission to practice before it. The requirement of the rules of practice that any person of ordinary intelligence can practice before this office is absurd. Every one comes within the limit of this restriction. If some good regulations were adopted in this line, the office would not be two or three months behind in its work, as it is to-day, for much extra labor is thrown upon the office by the very ordinary intelligence of many of those practicing before it.

I thank you for your kind attention, and close, hoping I have not wearied you, and offering you an apology for the hurried manner in which this paper has been prepared.

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THE PRESIDENT:—I am sure we have listened with a great deal of pleasure to the very able and interesting paper of Mr. Fowler, which is the best presentation I have ever heard of some of the principal defects in the present administration of the patent office. He has pointed out also what is the prime cause of those defects. The difficulty being outside of the patent office, it lies with Congress. As a practising solicitor before the patent office for a good many years, I can endorse almost every word of what he has said. I think that this paper will be of a great deal of value to all our inventors, and nearly every electrician nowadays is an inventor and patentee. It is not as well known, as perhaps it might be that three-fourths of all the manufacturing business of the United States is founded on patents in one way or another, and it is very surprising that the manufacturers and patentees, constituting so very large and important a portion of the population, do not concern themselves more with this matter, and pay more attention to it and urge it upon the attention of Congress. No reform will ever be brought about of any importance until the people interested and who suffer by these defects will wake up and determine to have them corrected.

The paper is now before you for discussion. If no one wishes to say anything upon the subject presented, we will proceed to to the reading of the next.

THE SECRETARY:—The next paper in order is on Static Difficulties in Telegraph Wires, by Mr. F. W. Jones, who has made it the subject of study for a great many years.

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Read before the American Institute of Electrical Engineers, May 19, 1886.

STATIC DIFFICULTIES IN TELEGRAPH WIRES.

BY F. W. JONES.

The subjects of electro-static and electro-magnetic induction, having so many distinct features of considerable scope, each of which is treated at length in the various text books, it is not possible, within present limits, to do more than furnish a few of the recorded methods of overcoming the detrimental effects of induction upon signals over land and ocean wires.

Briefly stated, the detrimental effects are as follows:—On a long submarine cable it is impossible to record upon the most delicate instrument, a signal at the distant end at the same instant that it is given at the sending end, notwithstanding that electricity may be said to have a velocity too great to be assignable. This retardation in the cable is due to what Faraday, Siemens, Varley and others, in early days, termed the electro-static induction. The current, if sent into the cable in a succession of dots of equal duration and at equal intervals, will be prolonged to dashes at the distant end, commencing very faint, rising to a maximum strength, and then gradually tapering off at the close, after the battery has been removed. Should these dots be sent at shorter intervals they will appear at the receiving end as a continuous dash. When dots of the same duration and periodicity are sent through cables of the same length, their speed varies inversely as the product of the resistance and inductive capacity of the cables respectively, and the time of charging and discharging a cable varies inversely as the square of its length. Not only does the cable retard the signals, but the convolutions of the electro-magnetic apparatus, inserted in the circuit for the purpose of recording the signals, also exercises a retarding action on the current, due to electro-magnetic induction. As the signaling current passes around each one of the coils, there is an antagonistic or extra current aroused in all the adjacent coils flowing

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in a direction opposite to the signaling current, which it tends to extinguish and delay. In the straight conductor of the cable there occurs a similar but weaker effect. When the differential duplex system is applied to a cable there are, necessarily, sending and receiving instruments in circuit at each end, and instantly, after a signal is sent from one end, a ground is substituted for the battery, so that from the electrical centre of the cable near mid-ocean the current in the cable will divide, only about one-third of the current passing out at the distant end, and about two-thirds, returning through the ground above mentioned, at the sending end. As the receiving coils are always in the circuit, this returning current will produce a "kick" or false signal unless neutralized. The above-mentioned difficulties are experienced upon land wires, but in a much less degree, dependent upon the length, size and character of the wires, and their proximity to the earth and surrounding objects, and of the size and number of electro-magnets employed in circuit. There is also between parallel land wires an additional and serious difficulty, due to electro-magnetic induction, the magnitude of which depends upon the length and insulation of the wires and their distance apart, and on the strength of the signaling current, and the character of the signals.

About 1831, Michael Faraday coiled two insulated copper wires together around a block of wood, and connected one helix with a galvanometer and the other with a battery of 100 pairs, and discovered that when the battery contact was made and broken there was a sudden effect upon the galvanometer; "but that whilst the current continued to flow through the one helix, no galvanometrical appearance, nor any effect like induction upon the other helix could be perceived."

Faraday also discovered at this time all the other fundamental phenomenon of electro-magnetic induction. Nearly at the same time Joseph Henry discovered the phenomenon of the induction of a current upon itself in a long-coiled conductor.

M. Jacobi, of St. Petersburgh, Russia, is credited with being the first to introduce in a circuit a polarization battery, consisting of platinum immersed in sulphuric acid, for the purpose of counteracting the injurious effects of the residual magnetism in the electro-magnets. The line on which this was tried extended from St. Petersburgh to Moscow.

Werner Siemens published a very valuable article in the *Jour-*

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nal of the Society of Arts, April 23d, 1858, in which he ranks as one of the earliest investigators upon the subject of the static charge of underground wires. The following are some extracts from both English and American patent records, showing a variety of inventions for overcoming static difficulties, and I leave to those skilled in the science of patent law all questions relative to the validity of the patents or priority of the inventions.

Eng. Pat.

13062. E. W. SIEMENS, Sept. 23, 1850.
To prevent the wire from being charged with electricity (in the manner of a "Leyden vial"); a connection between the earth and the line wire is established at each end of the circuit by means of a thin covered wire of german silver.

1852.

LATIMER CLARK noted the phenomenon of the slow transmission of currents through submerged wires.—*Jour. Soc'y Arts*, April 23d, 1858, p. 356.

2885. WHITEHOUSE, Dec. 12, 1853.
"In one mode of working this manipulator the depression of the key establishes a short circuit, thus draining off the current from the line wires."

2956. LATIMER CLARK, Dec. 20, 1853.
"An improvement in insulating wires used for electric telegraphs, with a view to obviate the effect of return or inductive currents."

H. V. PHYSICK, Dec. 31, 1853.

The electrical charge assisting in long lengths of insulated wire is discharged to the earth without having to pass through the needle coil. In a reversing handle constructed with the above-described improvements a spring connected to the coil and line wire makes and breaks contact with the earth-plate before and after the transmission of the signal.

Jan. 20, 1854.

Faraday communicated the results of his inquiries respecting the Leyden jar charge of buried electric conductors to the members of the Royal Institution. He then showed that the electric currents which he employed traveled at the rate of only 750 miles per second along buried wires.

371. C. F. VARLEY, Feb. 16, 1854.
Key so arranged that when at rest a current is completed through the line wire, two of the springs being in connection with the battery poles respectively, one with the switch, and a third with the earth. On depressing the lever to transmit a signal the circuit is broken, an earth connection with the line wire made to discharge any residual electricity, and the current reversed.
"Peculiarly adapted to submarine or subterranean wires of great length."

1225. E. O. W. WHITEHOUSE, June 2, 1854.
"The induced or earth current in subterranean and submarine line wires is neutralized or dispersed in three ways, viz.:
1st. By alternating currents.
2d. By an adjusted amount of conduction to earth.
3d. By short-circuiting the current in order to divert it from the instrument; to obtain infinitesimal earth contacts platinum wires

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(respectively connected with the line wire and earth plate) are welded into a glass tube containing distilled water or other fluid."

2555. C. F. VARLEY, Dec. 5, 1854.

Condenser made of sheets of tinfoil and alternating sheets of oiled silk. Says they enable him to work to very great distances through submarine cables, subterranean wires, etc.

1318. C. F. VARLEY, June 9, 1855.

Invention consists of improvements whereby the speed of transmission is increased, and the distance of correct communication is extended, especially in the case of very extended submarine lines. "The key used for working by means of the patentee's, translates into the Morse system." In this key, when in a state of rest, the line wire circuit is completed through a relay by means of a tail-piece to the key lever which rests on a stop, the metal key lever being connected to the line wire and the stop to the relay, a small contact lever is pointed (by spring checks) on to the fore part of the key lever, and acts against stops, by which means, when the key is depressed, it puts the line wire into circuit with the most intense of two batteries, each of which are in connection with the earth. On the rising of the key the circuit of the larger battery is broken, the smaller battery sends an opposite current through the line wire, and finally the line wire circuit is completed through the relay.

When the key lever is quite depressed, and the line wire is being charged by the larger battery to signal at the distant station, the tail of the key lever comes in contact with one terminal of a resistance coil, the other end of which is in connection with the earth. This coil consists of a great length of fine iron wire, offering great resistance to the passage of electricity, and is employed to equalize the amount of charge which the wire received for different durations of the time of contact in making "dots and dashes."

The following difficulties are obviated by the use of the improved translators. The shortening of the short marks or "dots" made by a marking telegraph by repeated translation; this effect occurs in consequence of the time required to magnetize the electro-magnets and to move the armatures, it is also owing (in the case of submarine telegraphs) to the wire not being fully charged by the momentary depression of the finger-key at the transmitting station.

The lengthening of the long marks or dashes in submarine telegraphs, the first dash may give so great a Leyden jar charge to the wire, that its effect may not subside during some few subsequent contacts at the transmitting station, and thus makes a dash and a series of dots appear at the receiving station as one long dash.

The discharge of the Leyden jar charge (in the case of submarine telegraphs) by and through the relays; this may either take place through the receiving relay after a signal has been given and the line wire circuit is connected with the said relay, thus inducing so much permanent magnetism in its electro-magnets "as to derange it from printing with the weak currents from the distant station," or (in the case of a "translator" placed between two submarine circuits) from the second circuit to the first and from the first to the second, and so on alternately (through the respective relays), until the exhaustion of the batteries.

"When a signal was made at one end a current would be translated "into the second circuit, and when the battery contact was broken at "this end the translators would also break contact with the battery it "it had put on to the second circuit This second circuit having become "charged like a Leyden jar, would discharge itself through its relay, "and so translate back a current to the first station. The first circuit "would now become charged, and as soon as the second circuit had "become discharged, the charge of the first circuit, by returning "through the relay, would translate back again a current through the "second circuit.

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"Long submarine circuits, submarine cables of the usual dimensions, "200 or 300 miles in length. The length of time required to charge and "discharge, in consequence of the very great resistance offered by the "wire, is such that to communicate at a commercial speed it is necessary "to measure out the electricity in such a way that the intensity of the "charge shall not be greater with a long contact than with a short one. "This can be effected by the induction plates of my patent, dated Dec. "5, 1854."

Figure 34 of patent is an arrangement for effecting this purpose, and is represented as applied to a Morse machine for translation.

The line wire is first disconnected from its relay; secondly, it is connected to the primary coil; thirdly, both the line wire and primary coil are put in contact with battery when the electric current divides, a large portion going around the primary coil, the remainder through the secondary coil to line

"The circulation of the current round the primary coil induces a very "powerful but momentary current in the secondary, which gives a "charge or tone to the wire.

"The primary and secondary are made adjustable. When the signal "is completed, and the lever begins to rise, the battery contact is "broken. The consequent cessation of the current round the primary "coil causes a powerful current to circulate through the secondary coil "in the opposite direction, discharging the wire."

1855.

Mr. E. O. W. Whitehouse showed the effect of oppositely charging a submarine telegraph conductor in neutralizing the Leyden jar charge. —*British Association Report for* 1885.

2089. WERNER SIEMENS, Sept. 15, 1855.

Object of invention is to obviate the effect of the static or residual charge on long lines of submarine or subterranean telegraphs; consists of using a set of two insulated wires placed in close proximity to each other in the same insulated coating without using the earth as part of the circuit.

2103. C. T. and E. B. BRIGHT, Sept. 17, 1855.

Magnetic regulators adjustable at various distances from the needles increase the sensitiveness of the needles, and protect them from the effect of return currents. In using very powerful secondary currents an arrangement is adopted to protect the receiving coils from the effects of the return currents.

A (magnetic) arm connected with the line wire is free to vibrate between two stops, one connected with the coil terminal of the receiving instrument, the other with that of a supplementary coil and with the sending instrument. The normal position of the arm is in contact with the terminal of the receiving coil. The supplementary coil is so connected with the sending and receiving apparatus (with the receiving apparatus through the earth circuit) that the arm is not deflected by the action of the coil, when the first current traverses the line wire; the return current, however, deflects the arm, so that the supplementary coil is then in circuit, and discharges the return current. This last discharge replaces the arm in its normal position. Thus the receiving coils cannot be in connection with the line after any current has been sent, until the line has discharged itself by passing through the supplementary coil.

1726. E. O. W. WHITEHOUSE, July 21. 1856.

Employs one insulated wire as a return wire in lieu of earth circuit.

—— C. F. VARLEY, Dec. 24, 1856.

Improvement in induction coils, also key arrangement in connection with the same.

In one arrangement the currents induced in the secondary coil, both by the breaking and by the making of the primary circuit, are turned in

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one direction, thus sending two currents in the same direction along the line wire by the depression of the key, and two currents in the opposite direction during the rising of the key to its normal position.

To enable the currents to be transmitted in the above described manner, the key lever and its tail, respectively, make contacts with studs in contact with the other pole. A commutator arrangement, or an arm projecting vertically from the key lever, enables both the secondary currents to be transmitted in the same direction along the line wire. In another form of key adapted for long submarine circuits, a handle or winch is placed on the axis of a contact making a cam wheel, and of a commutator arrrangement similar in principle to that of the first key.

A key for working with a primary coil only. A key lever and its tail (connected to the line wire) is so mounted, in connection with springs and studs that on being depressed it breaks contact with the relay, then makes contact with one terminal of a primary coil whose other terminal is connected to the earth, then with a battery pole as well as to the coil, the remaining battery pole being in connection with the earth. On rising to its normal position, the battery contact is first broken, thus allowing a momentary induced current from the coil "to flow through the line in the opposite direction to the original current."

The action during the depression of the key is, therefore, to send a divided primary current along the line wire, and during the rising of the key to discharge the line wire from the effect of induction. The same general arrangement may be used for translation.

The key with only the primary coil, "is of great use for submarine lines, "for, on the first moment of making contact, the coil opposes a greater "resistance to the current while it is being magnetized than when it is "charged, consequently the current flowing down the line is more "intense at the first moment than afterwards. This neutralizes, to a "considerable extent, the effect of induction in the line wire, while the "reverse current discharges the line. For overground wires, working "with Morse or other relays, a beneficial effect is experienced, enabling "the communication to be carried on more rapidly. I use the same "general arrangement for translation."

211. PIER ALBERTO BALESTRINI, Jan. 23, 1857.

Winding around the centre core of submarine cables on which the insulated wires are laid, a thin copper wire in long, open spirals, in order to carry off the induced electricity from the insulating material.

EDWARD HIGHTON, Jan. 26, 1857.

Invention consists in using an additional battery to neutralize the influence of the line current on the instrument at the sending station. The neutralizing current from the additional or counteracting battery, is brought into action by a short circuit made at the same time as the line circuit is completed, in the opposite direction, and only including the coils of the sending instrument. According to this arrangement "there is no necessity for a separate counteracting coil wire (as usually employed), and each counteracting battery adds to the power of the effects produced by the main battery on the distant coil.

329. SIR WM. THOMSON, Feb. 20, 1858.—Sec. 15th.

In working through a telegraph line of considerable resistance, in both directions at once, to avoid the consequent violent action of the receiving instrument at the transmitting end, by transmitting signals from that end through it, the said receiving instrument is thrown out of circuit "during certain parts of the time during which a signal is being transmitted from that end." The time during which the signal is transmitted is regulated by the arrangement of cams and springs of the key. The time during which the receiving instrument is thrown out of circuit is regulated by a separate wheel on the same arbor with proper cams.

2180. C. W. SIEMENS, Sept. 30, 1858.

Avoiding the Leyden jar charge to a wire by allowing the Morse in-

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struments to mark signals by dots only, instead of by dots and strokes. At a second row of dots the charge of the wire is discharged. A machine is used similar to that described in 2366 of 1854.

Eng. Prov. Pat.

2250. JNO. TATLOCK, Oct. 9, 1858.

In order to obviate the influences produced by the action of the Leyden jar charge in submarine and underground telegraph conductors, the conductor is made altogether of metal, instead of employing the earth circuit for half the conductor. The two wires which respectively conduct the forward and return current are separately enclosed in and surrounded with gutta-percha.

Eng. Pat.

2515. Communicated to R. BROOMAN, Nov. 9, 1858.

So arranging of the battery force that electric currents can be transmitted to any required distance without limitations, by the action of counter currents when the circuit is broken, the said counter currents being the effects of the Leyden jar charge of a long or subaqueous conductor. The battery is divided into two or more groups, one of which is at all times in perfect circuit, but without sufficient power to affect the receiving instrument. The circuit is continuity preserving.

181. LATIMER CLARK, and JNO. MUIRHEAD, Jan. 20, 1859.—Part 4.

A galvanometer that is wound with a long coil of fine wire, has its terminals connected respectively with those of a galvanic battery and with the ends of a short auxiliary coil of fine wire, thus providing two circuits for the electric current; as the relative proportion of the two quantities always remains constant, a measure of the whole quantity is obtained. The auxiliary coil is useful for reducing the strength of the return current in submarine cables.

607. WM. CLARK, March 8, 1859.—Communication from A. H. S. Treve.

To obviate some of the Leyden jar effects in submarine cables.

465. SIR C. T. BRIGHT, Feb. 20, 1860.

Return current may be discharged between the separate signals.

A key combined with a switch is employed, by which the conductor may be cleared of the residual effects of a former current, and the circuit changed for receiving, at one operation.

1209. C. M GUILLSMIN, May 16, 1860.

Leyden jar charge of a long submarine conductor is not avoided, but is prevented from discharging itself between each signal, etc.

2047. THOMSON and JENKIN, Aug. 25, 1860.

The transmitting end of the line during the pause separating any two letters, words or sentences, is connected with a third source of electricity, at a potential intermediate between those potentials used in connection with the first and second contacts.

2116. C. W. HARRISON, Sept. 1, 1860.

A mode of dissipating the residual or Leyden jar charge of submarine conductors. Use of primary and secondary coils.

3453. C. F. VARLEY, Dec. 26, 1862.

1st. For working long submarine lines certain arrangements of induction plates with or without resistance coils, or induction coils at the transmitting end, are described and shown.

2d. Employing a "test" circuit, formed by induction plates and resistance coils, so adjusted to each other as to produce an artificial line, possessing the same amount of retardation as the cable itself.

This invention can be applied to almost if not all of the existing telegraph apparatus, viz.: It can be applied to the relay, or to the signaling instrument direct where no relay is used, as is the case with the needle telegraph, Thomson's reflecting galvanometer, Dignee's ink writer.

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Another part of my invention consists in the employment of what I term a test circuit, formed by induction plates and resistance coils, so adjusted to each other as to produce an artificial line, possessing the same amount of retardation as the cable itself at the signaling end. In some cases, however, it may be advisable to connect the cable to the earth through an induction coil, consisting of a large bundle of iron wire surrounded by a long length of fine wire, the action of which is as follows:

On reversing the battery connections, the induction plates and battery combined send a short impulse into the cable, which divides one portion into the cable, the other through the induction coil to earth. At the first moment the iron of the induction coil offers resistance to the passage of the current, consequently, during the first instant of time nearly the whole force of the current is applied to the cable. As the iron becomes magnetized to its maximum this opposition ceases, but the plates have become charged in the opposite direction, and there is no longer any current passing from them into the cable to maintain the magnetization of the wire, the demagnetization of which induces a current in the coil and discharges the cable. In this way each impulse is followed by a short impulse in the opposite direction. By connecting the two armatures of the induction plates with a set of resistance coils, this reversal of the current is followed by a weak reversal in the same direction as the original current. The induction coil is represented as wound with two wires.

2217. RICHARD LAMING, Aug. 29, 1865.

The suppression, either wholly or in part, of retarding charges on the signaling conductors of electrical telegraphs, by means of a second conductor placed for that purpose around each of them, and made to act indirectly upon it by possession of a permanent electrical charge of the same character as that in use for supplying the signal.

2015 W. S. ANDREWS, July 9, 1867.

In another part of this invention (in cases where intermediate relays are not employed to discharge underground or submarine circuits, or to neutralize at the termini the current of discharge) the contact-maker of the Hughes typewriter is prolonged by a separate piece working on the same vertical shaft, which, by an arrangement of connections, affects the required discharge. In sending neutralizing currents, an insulated disc, on the vertical shaft of the contact maker, is in contact with a spring from the neutralizing battery.

2875. CHAS. T. BRIGHT, Oct. 4, 1869.

At the sending end a key is employed, in which the line wire is placed to earth during the intervals between the signals. A greater resistance than is used at the receiving end is inserted when a signal is made.

1044. C. T. VARLEY, April 8, 1870.

Dr. Gintl and Frischens' double speaking apparatus and a hollow helix may be connected between the receiver and the line wire, the helix having pieces of iron inserted into it to remove the difficulty arising from the inductive capacity of the line. Helix to be of No. 26 silk-covered wire, 10 inches long, 1¼ inches diameter inside, 4 inches diameter outside. Small iron rods are placed in the helix.

1094. EDW. BULL, April 25, 1871. (Void.)

To prevent the current of the translator on the down line from passing through the coils of the translator on the up line. Condensers are used on cable circuits between the end of the line of each particular section and the earth.

2286. GEO. LITTLE, Aug. 30, 1871.

2d. The transmitting instrument is connected with the main line and with the earth. In the line leading to earth is one battery, the other battery is in a circuit united to the earth circuit at one side of the in-

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strument and to the main line at the other side. The negative of one battery is connected with the negative of the other. When the transmitting current is interrupted a reverse current is brought into action to clear the line, etc.

1207. GEO. LITTLE, April 22, 1872.
In submarine circuits the transmitter draws from a condenser at a distant station.

3344. J. B. STEARNS, Nov. 11, 1872.
In working submarine lines a condenser is placed between the relay and the resistance coil, one part of its metallic sheets being in connection with the earth.

3701. GEO. K. WINTER, Dec 6, 1872.
To obtain a high speed on long circuits.—Induction coil, etc.

761. GEO. K. Winter, March 1, 1873.
In duplex working. The static induction of the cable is counteracted by magneto-electric, or by battery induction. The induction may be initiated in a local circuit.

861. WM. C. BARNEY, March 10, 1873.
To prevent the tailings which sometimes occur in electro-chemical telegraphs, the positive current (or that which acts on the recording paper) is sent from the transmitter to the earth plate direct.

1508. T. A. EDISON, April 25, 1873.
To enable perfect signals to be transmitted and received in cables and long telegraph lines, an artificial line is placed on the opposite side of the receiving instrument to the cable. The receiving instrument is thus interposed at the point of no electric tension. The artificial line has the same resistance and capacity for providing static charges as that of the cable.
Between the receiving instrument and the earth one or more condensers or other accumulators of static electricity are interposed.

2870. J. B. STEARNS, Sept. 1, 1873.
It is a well-known fact in telegraphy that a submarine or subterranean telegraph wire cable or line, and in a lesser degree, also, a land line or suspended telegraph wire or line, as used in the transmission of signals, is not only a conductor of electricity, but is also a reservoir of electricity, in the sense that a Leyden jar is a reservoir.
In the system known as duplex telegraphy, this charge and discharge become troublesome, and condensers, and also induction coils, have been employed to obviate their effect upon the receiving instrument, as described in specification of Nov. 11, 1872. To render the charges equal a portion of the artificial line is included between the instrument and the condenser. Instead of the condenser, an induction coil may be used, or the instantaneous current from the sending battery, or a signaling battery.

3879. J. B. STEARNS, Nov. 27, 1873.
The condenser may be in the form of a submarine cable having great resistance and capacity to neutralize the effect of the static charge returned from the cable; mechanical, hydraulic or pneumatic means may be used in the receiving instrument. The static balance may be effected independently of the magnetic compensation; in this case the condenser may be of small capacity. The receiving wire of a differential receiving instrument may be used as a bridge wire of a duplex bridge, in connection with a condenser or induction coil, charged and discharged through the other wire; or the receiving instrument may be wound with three wires, two used in the ordinary (differential) duplex working, the static compensation being effected by means of the third wire. Instead of the third wire a separate compensating means may be employed.

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439. HENRY HIGHTON, Feb. 3, 1874.
The object of this invention is to obviate retardation in submarine cables.
At either end, or at each end of the line, also at an intermediate point thereof, an arrangement of pairs of plates is placed. The pairs are of metal or carbon, arranged as a galvanic battery, except that the plates of each pair are similar, and only one conducting liquid is used.
The electrical effect of this is similar to the mechanical effect of a spring in machinery, and immediately the electrical impulse ceases, the original electrical condition of the line is restored by the reaction of the plates, so as to be ready to receive a fresh impulse.

822. C. LEMAN, March 6, 1874.
A neutralizing current is sent between signaling currents.

1966. J. W. BROWN, June 5, 1874.
When transmitting a dash to the receiver, a strong current is sent, then an earth contact is made through the compensation pen, then a second strong current, and finally a reversed current. Permanent leak and magnetic shunt are shown, to obviate running the dashes and dots together, and to increase the speed.

2539. FOOTE and RANDALL, July 20, 1874.
To prevent tailings in an automatic telegraph two currents of opposite polarity are used, one for marking, the other for clearing the line.

4063. W. E. SAWYER, Nov. 26, 1874.
In an automatic telegraph a variety of devices are show to clear the line of tailings. At the cessation of an impulse, a perfect ground contact is made at the transmitting station Induction coils and equating batteries are included.

684. A. MUIRHEAD and H. A. TAYLOR, Feb. 24. 1875.
Improvement in the arrangement of a condenser for artificial lines of a duplex.

2351. W. E. SAWYER, June 28, 1875.
Battery, induction coils and resistance are introduced in the line at the receiving end to prevent the effect of tailings.

3374. JOHN MUIRHEAD, Jr., Sept. 27, 1875.
Eliminating disturbances or kicks that take place on receiving instruments in duplex working, by connecting up so the instrument is not immediately in connection with a circuit of high capacity. Increasing the capacity of the instrument, and arranging the sides of the bridge so as to have capacity to receive a charge; introducing a condenser of small capacity, with variable resistance, at a suitable point in the artificial circuit; placing the primary wire of an induction coil (in connection with the extremity of the bridge at one end) to earth, and to make its secondary coil a shunt to the recorder.

47. BENJ. SMITH, Jan. 5, 1876.
To prevent the "kick" an adjustable resistance is inserted at the termini of the cable, between the Wheatstone bridge, or other differential arrangement, and the artificial line.

2541. WM. DICKENSON, June 19, 1876.
Grounds the line when making a signal, causing a partial discharge of the line.

2564. A. and J. MUIRHEAD, June 21, 1875.
To make the cable and artificial line of a duplex similar, condensers, induction coil and resistances are variously disposed.

2941. J. W. BROWN, July 19, 1876.
To increase the speed of recording dots and dashes, employs positive

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and negative currents, which are transmitted through two rows of perforations in a paper strip, also making an earth contact.

American Patents.

125582. G. LITTLE, April 9, 1872.
A condenser in combination with electro-magnets, a rheostat and constant current.

126847. J. B. STEARNS, May 14, 1872.
In a telegraph apparatus for double transmission, the combination with the relay at each station of a condenser for the purpose of neutralizing the effect of the return current due to the static induction of the line.

134867. T. A. EDISON, June 14, 1873.
Neutralizing any earth or extra currents in automatic instruments, by a weak constant local current, preventing tailings and blurs in the writing.

135531. T. A. EDISON, Feb. 4, 1873.
Reversed induced currents from electro-magnets in branch circuits, neutralizes residual or extra current in main line, and thus avoids blurs or tailings.

136873. J. B. STEARNS, March 18, 1873,
Electro-magnets are arranged in a branch circuit from the equalizing magnet circuit, the extra currents therefrom neutralizing the static induction upon the receiving relay.

136876. J. B. STEARNS, March 18, 1873.
A shunt circuit is established around relay by action of its own armature lever, or by the lever of the sounder it controls, thus lessening retardations and ensuring decisive action.

141772. T. A. EDISON, Aug. 12, 1873.
Part of main current shunted through branch circuit. Effect of extra line current neutralized by an extra current from a local battery regulated by a rheostat.

141773. T. A. EDISON, Aug. 12, 1873.
Line kept statically charged by the main battery, whose circuit is made and broken with immense rapidity by a pulsator resistance, being such that these currents do not affect receiver; transmitter in shunt around the resistance. Receiver has two or more pens in circuits having shunts containing magnets of varying size.

141776. T. A. EDISON, Aug. 12, 1873.
The use of an opposition or secondary battery of weak power, at one or more points, to act in the main line in opposition to the pulsations from the transmitting instrument, to free the line of surplus or static electricity.

142486. G. LITTLE, Sept. 2, 1873.
Condenser or coil applied in a branch circuit to electro-magnet to neutralize effect of induced current.

147311. T. A. EDISON, Feb. 10, 1874.
States that the static charge of a line proceeds in both directions from the centre of the resistance of the line, and that at such centre the tension of the static or extra charge is zero, and that if the receiving instrument be placed at that point there will be no tailings; and introduces an artificial line between the receiving instrument and the earth, to balance the resistance and static charge.

147313. THOS. A. EDISON, Feb. 10, 1874.
Instead of a single electro-magnet in a shunt circuit to the receiving and transmitting instruments, as in his patent No. 135,531, a number

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are employed, with a switch, for throwing more or less into circuit, as in the case of the ordinary rheostat; also uses a rheostat in connection with the series of magnets.

153064. FOOTE and RANDALL, July 14, 1874.

In an automatic or chemical telegraph, the method of obviating tailings or blurs, and of effecting a ready discharge or freeing of the line, the same consisting of throwing upon the line, immediately upon each and every break in the circuit of the recording current, a current of opposite polarity.

In the *Telegrapher* (July 25, 1874), page 179, we find the following, over the signature of Geo. H. Grace.

"TO THE EDITOR OF THE NEW YORK TRIBUNE:

"As to the assertion that it is undisputed that Mr. Edison is the inventor of the device for neutralizing the after current, I have only to state that it is well known that Mr. Edison's claim to that invention is and always has been, disputed by me. I used the magnets at each end of the line for the purpose described, long before Mr Edison had anything to do with automatic telegraphy."

154479. C. H. HASKINS, Aug. 25, 1874.

Condenser in branch circuit, connected directly with main line circuit, so that extra charges from line and from condenser pass over the same wire in opposite directions.

157469. G. D'INFREVILLE, Dec. 8, 1874.

A sounder is utilized in a shunt circuit to counteract the static charge and discharge of the line wire.

158412. WM. E. SAWYER, Jan. 5, 1875.

A combination is made of a line, its battery and contact point of an induction coil connecting the line to earth, and throwing the secondary induced current into the line for the purpose of clearing the same of tailings.

160581. M. G. FARMER, March 9, 1875.

Claims that when the circuit of a duplex apparatus is closed, the static charge in the line causes the coil in the main circuit to momentarily affect the armature before the equating coil acts thereon, and introduces an inductorium, the primary coil of which is in a local circuit, the secondary coil being placed in either the line or equating circuit, so that when the sending key is operated the secondary currents will oppose the effect of the line charge and discharge.

165620. WM. E. SAWYER, July 13, 1875.

Throws into line battery currents of one polarity and an electro-magnetic induction apparatus, so arranged as to throw into the line currents of opposite polarity to the battery currents.

168243. T. A. EDISON, Sept. 28, 1875.

A signaling electro magnet is placed in the line with a secondary battery, and a shunt is placed around the instrument.

168385. T. A. EDISON, Oct. 5, 1875.[1]

Places an electro magnet in each arm of the bridge of a bridge duplex, and also establishes a supplementary artificial circuit, in which is also

1. On referring to the files for Sept. 1st, 1874, we find that Edison filed a caveat for the following arrangements for meeting static difficulties in both bridge and differential duplex systems. 1st. Subdividing the condenser and resistance coils in the artificial equating circuit to more nearly coincide with the line wire or cable in the time of charge and discharge. 2d. The arrangement of a subdivided artificial line, with a cable or land wire worked by induction from condensers. 3d. The introduction of an electro-magnet in a shunt around the coil of the relay in the artificial circuit. 4th. An electro-magnet is placed in the line circuit, between the dividing point and the coil of the differential relay; also, in the arm of a bridge duplex on the artificial side. 5th. A secondary battery is placed directly in the artificial circuit, between the relay and the compensating resistance. 6th. To obviate the detrimental effects of the discharge from relay magnets, inserted by mistake in the line and way stations, an electro-magnet is inserted in the artificial circuit, at such a point as will allow its charge and discharge to balance the one in the line. 7th. The primary coil of an inductorium is inserted in the artificial circuit, between the relay and the earth, and the secondary coil is connected to an extra electro-magnet, which acts on the relay armature in opposition to the line relay electro-magnet, so that it tends to counteract the effect of the static charge and discharge of the line.

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placed an electro-magnet, the extra currents of which are intended to neutralize the static charge and discharge of the line. This invention is disclaimed by Mr. Edison on November 19th, 1878, on the ground that it is set forth in a previous application dated Sept. 1st, 1874.

178223. T. A. EDISON, May 30, 1876.
Shows a mechanical compensator, consisting of a flat spring attached to the armature lever of a differential relay, and a notch lever operated by a local circuit. The notch lever engages with the spring to mechanically neutralize the effect of the static charge and discharge of the line.

190898. GEO. B. PRESCOTT, May 15, 1877.
To prevent the signals being shattered on the neutral relay in a quadruplex telegraph when reversals of current are used, an electro magnet is so located as to pull on the armature of the neutral relay in the same direction as the line magnets. This auxiliary electro-magnet is connected up in a condenser shunt around a rheostat in the bridge, so that the received currents give momentary energy to it through the charge and discharge of the condenser.

196833. W. E. SAWYER, Nov. 6, 1877.
A regulator periodically put the line to earth or to a discharging battery, for effecting the static discharge of the line.

207724. T. A. EDISON, Sept. 3, 1878.
In a quadruplex the artificial line is provided with two or more condensers of varying capacity, and a like number of rheostats of varying resistance, for regulating the charge and discharge of the same to correspond with that of the line.
An auxiliary electro-magnet is placed opposite the electro-magnets of the neutral relay, to act in conjunction with the retractile spring. A polarized relay, included in the bridge wire, operates this auxiliary electro-magnet in a local circuit, through either its front or back stop, so that during reversals of the received current, the local circuit is momentarily broken and the false signal avoided.

201374. CHARLES H. WILSON, March 19, 1878.
The detrimental effects of induced currents between lateral line wires are neutralized upon single wires by the interposing condensers and induction coils between them; and upon duplex and quadruplex wires by interposing condensers, resistance and retarding coils between the artificial circuits, and making their discharge equivalent to that of the line.[2]

209241. T. A. EDISON, Oct. 22, 1878.
The drawing shows a bridge quadruplex system, in the cross wire of which a polarized relay, neutral relay, and a rheostat are included. Around the rheostat is placed a condenser, which, like the relays, is only affected by the received currents, and acts upon the neutral relay, so as to steady its signals during reversals.

217304. BENJAMIN THOMPSON and CHARLES SELDEN, July 8, 1879.
A condenser is arranged to form a shunt around the duplex relay coil situated in the line circuit.

225140. F. W. JONES, March 2, 1880.
A condenser is arranged to be charged by a separate battery, and to be discharged directly into the line through a system of duplex, employing single coil relays. This only obviates the effect of the discharge of the line wire.

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2. In the "Journal of the Society of Telegraph Engineers" for 1879, Professor D. E. Hughes has a very instructive paper on the effects of induction between lateral wires. W. H. Preece, Professor Bell, and others, have also made valuable contributions on the same subject, which has been dealt with more particularly with reference to the telephone. As many patents have been obtained, both here and abroad, for shielding that most delicate instrument—the telephone—from induction effects, I will leave this very extensive branch of the subject to others more conversant with it, for elucidation.—F. W. J.

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238912. F. W. JONES, March 15, 1880.
A shunt of double-wound resistance, to obviate the effects of extra currents in a telephone circuit.

230802. ALEXANDER MUIRHEAD, Aug. 3, 1880.
A method of adjusting artificial lines or compensating circuits in systems of duplex and multiplex telegraphy; which consists in inserting an adjustable leakage circuit in the artificial line, and varying its positive to closely imitate the conditions of the line wire. This improvement was patented in England Feb. 24, 1875.

231904. J. E. FENN, Sept. 7, 1880.—Also,

236321. J. E. FENN, Jan. 4, 1881.
An adjustable electro-magnet is placed in the line next to the receiving instrument, to neutralize the static discharge of the line.

234347. T. F. TAYLOR and GERRITT SMITH, Nov. 9, 1880.
A condenser is placed in a shunt between the line and earth at the sending station, for the purpose of prolonging the duration of the outgoing currents.

237595. CHAS. A. RANDALL, Feb. 8, 1881.
A device for sending alternate impulses to line, and thus free it of tailings.

238094. GEORGE D'INFREVILLE Feb. 22, 1881.
The capacities of the main and artificial lines are made equal at the instant of transmitting a signal, by automatically diminishing the resistance in the artificial circuit for an instant only, and then restoring it to its normal condition.

238399. F. W. JONES, March 1, 1881.
A shunt is placed around an electro-magnet, to prevent its extra currents from destroying the voice waves of telephonic communication.

238448. GERRITT SMITH, March 1, 1881.
A device for killing the static discharge. One pole of a condenser is attached to the main line and the other to a supplementary artificial line, which passes to ground through the coils of the home relay, thus permitting the re-acting discharge of the condenser to neutralize that of the main line.

244218. S. D. FIELD, July 1, 1881.
To avoid the difficulty of the static charge and discharge of a line on a duplex, the receiving instrument is short circuited, and the bridge wire (in which said receiving instrument is located) is broken for an instant, both on the opening and closing of the home key.

253154. C. L. BUCKINGHAM, Jan. 31, 1882.
To avoid troubles due to static charge and discharge in a duplex, a normally closed bridge unites the artificial and main lines at points beyond the differential receiving instrument, and the static charge and discharge are caused to act equally upon both coils of the receiver, by reason of the bridge. This bridge is broken by a signal from the distant station.

257499. J. W. LARISH, May 9, 1882.
In a duplex an electro-magnetic shunt is provided around the artificial line coil for avoiding the static difficulties, and the battery is momentarily connected through the home relay at the instant its connection with the main line is broken, for preventing false signals due to extra current charge.

258366. C. L. BUKKINGHAM, May 23, 1882.
An arrangement for rendering the receiving relay of a differential duplex system insensible to the effects of the inductive charge and dis-

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charge of the line, by causing both inductive charge and discharge, respectively, to be divided through the two oppositely wound coils of the differential relay.

258367. C. L. BUCKINGHAM, May 23, 1882.
Introduces in the line and artificial circuit, an extra differential relay, whose lever and back stop forms a bridge conductor, between the main and artificial line next to the main line, and at points of equal potential of the outgoing current.

258428. F. W. JONES, May 23, 1882.
In a duplex a branch line, including an electro-magnetic inductor, extends from a point between the main line and the receiving instrument to earth.

253636. J. E. FENN, May 30, 1882.
To prevent false signals upon the receiving instrument of the home station, caused by the extra current set up by the receiving instruments of a distant station, the artificial circuit is provided with electro-magnetic induction apparatus, interspersed with the equating resistance, so as to imitate in the artificial circuit the effects of the distant extra currents coming over the main line through the relay.

258957. B. THOMPSON and C. SELDEN, June 6, 1882.
A condenser is placed in the artificial line, between the transmitter and the receiving instrument, and so arranged as to utilize the charge and discharge of both faces in overcoming static disturbances.

259106. DILLON and BROWN, June 6, 1882.
In a system of tension duplex a device for overcoming the static discharge, by sending the secondary current of an induction coil through one coil of a double-wound relay—the primary coil of inductorium being in the local circuit of transmitter.

260208. F. W. JONES, June 27, 1882.
In a tension or two relay duplex an artificial current is formed around the relay nearest the line in the same direction as the line circuit. An electro-magnetic induction is included in the artificial circuit, and opposes, by its extra current, the effects of the line static.

261916 S. D. FIELD, Aug. 1, 1882.
To avoid the effects of the static charge and discharge in a duplex, an electro-magnet, having a closed magnetic circuit, is placed in the main line near the receiver, and provided with a permanent magnet for adjustment with relation to the cores of the magnet, and a normally open shunt around the inductor, and a device actuated by the transmitter to close the shunt at the instant the current is set to or taken from the line.

268317. BENJ. THOMPSON, Nov. 28, 1882.
The poles of a condenser are connected to the main and artificial lines respectively at points of different potential.

280703. A. MUIRHEAD, July 3, 1883.
The potential of the battery applied to the artificial line of a duplex is modified by an electro-magnetic shunt, a separate battery being used for signaling on the line.

828667. B. THOMPSON, Oct. 16, 1883.
In a duplex a short circuit is completed around the sounder at the instant of the flow of the static charge and discharge.

291318. S. D. FIELD, Jan 1, 1884.
In a duplex an electro-magnetic inductor is placed in the line circuit, and a shunt connecting the line with the transmitter is established around the line coil of the relay and the inductor.

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291096. }
291097. } C. SELDEN, Jan. 1, 1884.

A local auxiliary neutralizing coil and a condenser are so connected to the relay and transmitter of a duplex as to be brought into action in opposition to the static discharge at the moment of its discharge.

293110. T. F. TAYLOR, Feb. 5, 1884.

An opposing battery, having less electromotive force than the transmitting battery, is placed in the line at the receiving station.

300781. F. W. JONES, June 24, 1884.

A static compensator or inductorium has one coil included in the main line circuit and the other coil in a supplementary convolution of the receiving instrument, so that secondary currents of the secondary coil are reverse to the static charge and discharge of the line.

304106. F. W. JONES, Aug. 26, 1884.

Duplex or quadruplex relays with three coils are employed, two of which are connected up as usual for the line and artificial circuit. A second artificial circuit, starting from the dividing point next to the transmitters, goes around the third coil of the relays to earth in the same direction as the line coil. In the second artificial circuit are rheostats and electro-magnetic inductors, so graduated as to generate extra currents equal and opposite to the static charge and discharge of the line.

309571. }
309572. } C. SELDEN, Dec. 23, 1884.

An auxiliary electro magnet in a local circuit is arranged to exert its force on the armature of the line electro-magnet in opposition to the coils of the relay. The transmitter momentarily closes a local battery around the auxiliary coils at the instant the discharge line discharges. Also an ingenious arrangement of polarized sounder, reversing relay, battery and local circuit, so as to withdraw the local current from the sounder at the instant of opening or closing the sending key.

313787. H VAN HOEVENBERGH, May 10, 1885.

In a quadruplex telegraph a method of preventing false signals upon the receiving instrument, controlled by the armature of the neutral relay upon the reversal of the main line current, which consists in momentarily neutralizing the local current, actuating said receiving instrument by means of an opposing electromotive force.

319428. GERRITT SMITH, June 2, 1885.

In a quadruplex telegraph system, in which reversals of current are employed for the transmission of one set of signals, a neutral relay provided with two coils, one of which is embraced in the main line and the other in a branch, which includes a condenser, and is connected with the main line between the neutral relay and the earth and with the earth.

310684. F. W. JONES, 13, 1885.

A static compensator for duplex and multiplex telegraphs, consisting of an inductorium, one coil of which is in circuit between the main line and the point of division of the main and artificial lines, or beyond the point of division of the main and artificial lines, while the other is in a closed circuit, including means for counteracting the effects of the static charge and discharge current upon the receiving opposite.

320987. }
321404. }
322333. } F. VAN RYSSELBERGHE, June 30, 1885.—July 28, 1885.
323239. }

The method of rendering telephonic or other electric currents—whether primary, induced or derived—inaudible in telephones, consisting in rendering gradual the emission and extinction of the telegraphic

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or other electric currents, by the introduction of an electro-magnet in the circuits; also by the attachment of condensers.

322692. P. B. DELANY, July 21, 1885.
The combination of a main line synchronously actuated apparatus connected with each end of the main line, a table of contacts and a rotating circuit, complete at each end of the line, which traverses over the table of contacts and successively places the main line in connection with each of said contacts. Static discharge contacts arranged between the first-named contacts, and connected together and to earth, and a resistance between the static discharge contacts and the ground.

322739. L. O. MCPHERSON, July 21, 1885.
In a quadruplex telegraph a condenser having one pole connected with the conductor leading to the said instruments, and the other connected with the earth, whereby said condenser will receive a charge opposite to the static charge occasioned upon the main line.

327097. ALEX. MUIRHEAD, Sept. 29, 1885.
A supplementary condenser and rheostat are included in a shunt around the condenser in the artificial arm of the bridge.

326892. F. VAN RYSSELBERGHE, Sept. 22, 1885.
To prevent false signals or reversals, a relay is placed in a branch wire from the main line to a condenser, the other side of which is to earth. The local points of this relay control a battery, which actuates a supplemental or holding electro-magnet, acting upon the same armature lever as the neutral relay in the main circuit.

The PRESIDENT: Although perhaps Mr. Jones's paper is not as interesting to read to an audience as some of those which preceded it, I think those who have had occasion to do work in that line will appreciate the amount of labor he has bestowed on it, and recognize its value when incorporated in our records. Every increase in the capacity of a wire renders the elimination of these static difficulties more and more important, and as time goes on the value of a contribution of that kind will become better and better appreciated.

During our meeting last evening, a Committee was appointed to take into consideration the propriety of some action by this Institute in relation to the British Standard Wire Gauge. This wire gauge has been endorsed and recommended by the National Electric Light Association and the National Telephone Exchange Association. I do not recollect the official details of their action, but that will appear in the course of the proceedings, and the matter was referred last evening to a Committee of five, who were instructed to report if possible at the meeting to-day. I will now ask that Committee if they have any report to make.

The SECRETARY: The report is nearly ready. It is not quite in shape, but we will have it so before the meeting closes, and also the report of the other Committee on monthly meetings; so that if you will go on with the final paper on Secondary Batteries, the

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Committee will be ready to report probably when the reading of that is finished.

The PRESIDENT: We will postpone the consideration of that until after we have read the paper. We have two more papers down on our programme, one by Mr. Bauer on Secondary Batteries for Light and Power, and the other by Mr. Byllesby on Incandescent Lighting Systems. Mr. Byllesby unfortunately has been so much occupied that he was unable to get his paper ready in time, so that we shall be deprived of the pleasure of listening to that. Mr. Bauer's paper I will ask Mr. Mailloux to read, as he is especially familiar with the subject.

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SECONDARY BATTERIES FOR LIGHT AND POWER.

BY A. H. BAUER.

So much has been written of the the theory of secondary batteries, that I assume it would be more interesting to the members of this Institute to confine my remarks to a history of what has been done practically during the past three years with the Faure battery at Baltimore.

In May, 1882, a set of Faure batteries was brought from Paris by the steamer Labrador, and sent to Baltimore. This battery was composed of 60 cells, each containing ten plates, with a supposed capacity of 200 ampère hours at an E. M. F. of 2 volts. The plates were made of sheet lead, 9½″ long, 5½″ wide, and $\frac{1}{16}$″ thick, mechanically perforated with 400 holes $\frac{1}{8}$″ diameter. They were coated with a paste made by mixing sulphuric acid and red lead, which was held in place by wrapping the plate in felt. They were set in lead-lined boxes, with the terminals of five plates joined together with brass clamps to form the positive, and the remaining five likewise connected to form the negative poles. Twenty-four of these cells were placed on exhibition in the offices of the Electric Storage Co., and arranged to run a lot of Edison B lamps, small motors, etc. The charging machine was an Edison Z A dynamo, located about half a mile from the office.

These batteries gave satisfactory service for about six months, when they failed rapidly—first one, and then another, would refuse to store, until nearly all had become useless. Examination disclosed many causes for the failure, which at that time was imperfectly understood. One of the defects was the interposition of felt between the plates, which increased the internal resistance; and after a time the felt got rotten and fell off, causing a short circuit.

Realizing these and other defects, the matter was taken in hand with the intention of evolving a practical battery, with what results the following will show:

The first plate giving promise of success was cast in an iron mould; its dimensions were 12½″ long, 9½″ wide, and $\frac{3}{8}$″ thick, weighing 6½ lbs. They were in the form of grids, having 480 holes $\frac{3}{8}$″ square. These holes were filled even with the surface of

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the plate with 5½ lbs. of a mixture of red lead and sulphuric acid, and allowed to dry. Twelve of these plates (6 positive and 6 negative) were placed in a rectangular box lined with a mixture of pitch and asphalt. The plates were separated by pine boards $\frac{3}{16}$″ thick. Forty of these cells were connected in series with an Edison 110-volt machine and charged with a current of 50 amperes for 300 hours.

From the first, several difficulties presented themselves, one of which was that the wood boards prevented a free circulation of liquid between the plates, causing the charging current to pass from one plate to another at one or two points where the resistance was least. Another was the constantly increasing resistance due to the sulphating of the copper connecting strips joining plates and cells together. The next step was the removal of the wood boards and the substitution of pine strips ¼″ square section, and 10″ long; four of these were placed between each pair of plates; the copper connectors were painted with an insulating paint.

These changes made a vast improvement in the working of the battery. A number of cells that before had persistently refused to receive or hold a charge, now became active, and could be relied upon to give a satisfactory current. While with the same plates separated by boards, the internal resistance of the cells averaged $\frac{1}{160}$″ ohm, that of the same cells with ¼″ strips fell to $\frac{1}{500}$ ohm. In the course of time, however, the copper connecting strips gave trouble. In spite of the insulating paint, the acid would attack the strips, forming sulphate, and developing a high resistance.

While much had been learned from these experiments, and some progress had been made towards a practical battery, yet it was seen that the great weight (250 lbs.) per cell of those in service must be reduced. About this time the writer visited London, for the purpose of studying the improvements made by the Electric Storage Company at Millwall. Immediately upon his return the subject was taken up anew. It was found necessary to make numerous changes. While the cast perforated plate was still used, its dimensions were reduced to 10″ long, 9½″ wide, and $\frac{3}{16}$″ thick, and its weight to 2½ lbs. These plates were pasted with 2½ lbs. of active material. The only size cell made at that time was termed an A 1 h. p. cell.

$$\frac{E \times C}{746} = El.\ h.\ p.$$

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and consisted of 16 plates (8 + and 8 —) in a lead-lined box, separated by pine strips $\frac{1}{4}''$ square section.

They had a capacity of 370 ampère hours at 2 volts E. M. F.,

$$\frac{2 \times 370}{746} = 1 \textit{ El. h. p.}$$

Instead of using co per or brass rods, or strips for connecting the plates and cells together, lead was substituted. This battery showed a great improvement over the first made. It was found to be thoroughly reliable. It would retain its charge for months without practical loss. Numerous experiments were made to determine their capacity and efficiency. These tests have always been of a practical nature—two of which I will quote: 32 cells were charged with 20 ampères for 20 hours. A carefully calibrated ammeter was kept in circuit during the entire time.

To discharge, the battery was connected to two Weston arc lamps in series, and a current of 20 ampères for 16 hours was obtained before the E. M. F. fell to 1.5 volts per cell; this was equal to an efficiency of 80 per cent.

The same test was repeated, except that Edison B lamps were u ed for the discharge with a return of 340 ampères or 94 per cent. before the E. M. F. had fallen to 1.5 per cell.

On May 1, 1884, an installation of 3 h. p. cells for supplying 255 16 c. p., 70-volt lamps was made at the Academy of Music, for lighting the stage. This battery is located in the cellar, each cell consists of 48 plates in lead-lined boxes and has a capacity of 1,200 ampère hours at an E. M. F. of two volts. The location is not the best for high efficiency—a well occasionally overflows, thoroughly wetting the framework on which the battery rests as also the wooden boxes themselves, causing at times, serious leakage and loss of current. Even under these adverse circumstances the battery is still in service and doing remunerative work.

The lamps used are the Weston 70 volt $\frac{9}{10}$ ampère, and comprise 98 footlights of various colors, five borders of 20 lamps each, the balance being distributed among the dressing rooms, stage entrances, etc. Each border and the different colored footlights is on its own circuit and controlled by its own switch. An arrangement is used whereby the light can be increased or diminished from the stage by adding or subtracting any number of cells from one to 16 as desired, thus producing all the effects that heretofore had been done with gas. This battery is charged every

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night with two 10-light arc machines, giving a total of 50 ampères.

It is of course understood that during the time of a performance a current of about 230 ampères was required to maintain the lamps, of which the dynamos furnished 50 and the batteries the balance. As this demand was not continuous during a performance, the total time not being over four hours in 24, it is possible by running the two machines for an average of 10 hours per day to keep the battery thoroughly charged and always ready to furnish current when required. This plant has been in daily service for two years. At this writing another installation of 3 h. p. cells supplying 300 38-volt Swan lamps is being made for the Crescent Club of Baltimore, and will probably be in service within the next month.

Some work has been done with the batteries for cautery, faradic and constant current purposes. For the cautery a current of from 10 to 30 ampères is required, depending upon the length of platinum wire to be heated, and as they are in service not more than one minute at any one time—small capacities are required. These batteries are made up with plates measuring 7″ long, 5″ wide and $\frac{3}{16}$″ thick, weighing two pounds. For office practice they have a capacity of 200 ampère hours, and weigh 43 pounds; those made portable have a capacity of 25 ampère hours, and weigh eight pounds. They usually run from three to six months without recharging.

A very interesting experiment was made a short time ago with 50 secondary cells on the wires of the Western Union Telegraph Co. A wire from the battery was run to the Baltimore office to which were connected 38 Morse and three gold and stock circuits, the resistance of which varied from 50 to 6,000 ohms. At the same time three incandescent circuits consisting of 56 Maxim 25 c. p. and 24 Edison 8 c. p. lamps were also being supplied from the same battery. The number of cells of primary battery displaced was 1375 gravity and 110 carbon. The experiment was continued daily for more than one week.

Less than one year ago a battery consisting of 49 four-plate cells, having a capacity of 100 ampère hours, was taken to the Daft electric railway station near Baltimore, and placed on one of the motor cars used in that system and connected to the motor and switches in the usual way. An extra switch being used, however, to vary the E. M. F. by adding or subtracting a certain number of cells. The total weight of car, motor, batteries, etc., was about 5½ tons. Three trips of about one mile each was made.

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As this experiment was made merely to show that the batteries could be used for the purpose no tests were made. Encouraged by the success of that experiment a 20-foot car weighing 5,400 pounds was borrowed from one of the Baltimore railway companies, and taken to the Viaduct Manufacturing Co.'s place, where an eighth of a mile track was laid. The following described system was devised:

It consists of two beams extending between and resting on bearings on the two car axles. These beams carry a motor, counter shaft, and gearing. The armature shaft of the motor is extended and carries six inch pinions on each end which mesh into 20″ counter gears. On the counter shaft is a six inch pinion which meshes into a 24″ gear on the front axle of the car. The motor is wound in three sections, each section is connected to the battery by a double three point switch located on the platform by which one, two, or three sections can be connected in circuit depending upon the amount of power the motor is required to develop.

In all previous experiments with batteries for power purposes the resistance of the motor was constant, the variation of power being had by adding or subtracting a certain number of cells. In the present system the number of cells in circuit is constant, and the current is varied by varying the resistance of the motor. In the former case a number of cells were exhausted, while a number were in good condition, and at the end of a certain time an irregular battery was the result. In the latter each and every cell does the same amount of work and all are discharged alike. Although the tests of the system are as yet incomplete, the following data may convey some information.

The resistance of one section of the motor plus that of the armature is .57 ohm, of two sections in multiple are .32 ohm. and of three sections .20 ohm. The counter E. M. F. is respectively 70, 90, and 100 volts at 800 revolutions of the armature. The battery gives an E. M. F. of 120 volts, the internal resistance is .06 ohm. The track is about one-eighth mile in length and commences at the foot of a 1 in 20 grade on a curve of 45 feet radius. The total weights of the different parts of the system is as follows:

Car	5,400	pounds.
Motor	923	"
60 cells battery	5,400	"
Gearing	900	"
Total	12,623	pounds.

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This car has been running almost daily for the past two months, and with the exception of an accident due to the irregularity of the track causing a run off when coming down grade on the first trip, no trouble has occurred, and no changes or alterations have been found necessary. Sixty cells of battery of a total weight of 2,580 pounds are now being tried. The large size gives a continuous run of 36 miles. It is expected that the smaller should be able to propel the car 18 miles.

As before stated the tests are very incomplete, and I regret I am not able to give you data sufficient to judge of the merits of the system.

There are many experiments that we were obliged to make in order to become thoroughly acquainted with the battery, and which it would only take up your valuable time to mention. I will, therefore, merely add a few words in regard to certain erroneous ideas that have been held by a large number of people respecting batteries in general and storage batteries in particular.

When the announcement was first made of the great discovery by Camille Faure, it was also said that the secondary battery was a simple contrivance composed of lead and sulphuric acid put together in certain proportions placed in wooden boxes, carted around the city and delivered to subscribers at stated times, that it could be placed in the cellar, vault, or some other out-of-the-way place, and without any attention whatever would always be ready to furnish current at any moment either day or night. Such ideas instilled into the minds of an unthinking public have done great injury to the battery interests. A little thought and study would have shown the fallacy of these promises.

A secondary battery requires precisely the same amount of care and attention as a dynamo or other source of electrical energy doing the same amount of work. As a matter of comparison, suppose the plant at the Baltimore Academy of Music to be run from a dynamo capable of maintaining 255 16 c. p. lamps. In addition to the dynamo a 30 h. p. engine and boiler will be required. Now, to properly take care of the installation, it will be necessary that at least one man give it his entire time and attention. At stated times the boiler will be thoroughly examined. He will probably use a compound in the feed water or take other means to remove scale. He will watch his gauges very closely to see that the proper quantity of water is in the boiler. His engine will be set perfectly level on at least a six-foot foundation, and all

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its moving parts closely watched to prevent an accident and stoppage. If he be attentive the engine will be kept scrupulously clean. His dynamo will receive as much if not more attention than any other member of the plant. He will use a good quality of oil in its cups and see that it feeds properly to prevent undue friction in the bearings. He will be extremely careful to prevent dirt, dust, etc., accumulating on the machine, and whenever possible he will remove the armature, clean it of dust and dirt, and give it a coat of shellac. If he be attentive, he will see the necessity of closely watching all parts of the plant. Compare all this care and attention absolutely required by a direct lighting plant to that heretofore supposed to be required by a secondary battery doing exactly the same amount of work.

How is it possible to place a battery in a damp cellar, and with little or no attention expect it to do satisfactory work at the rate of 25 h. p? Batteries as now constructed have an E. M. F. of 2 volts and an internal resistance varying with the number of plates per cell. Given a battery of 100 cells (3 h. p.) we have a total E. M. F. of 200 volts and an internal resistance of $\frac{1}{3\,0}$ ohm. With this comparatively high potential and low resistance what is to prevent a constant loss of current by creeping, if such a battery is located in a cellar, and covered with dirt and moisture? I have seen batteries working under such unsatisfactory conditions. On account of its great weight and the fact of sulphuric acid being used, it is best that the battery should be placed in a cellar—but the cellar should be dry and clean and well ventilated.

The first and most important point to be observed is to carefully insulate the cells from each other and from the earth. The plan I have adopted is to use 4x4 scantling well painted with asphalt varnish—the scantling is insulated from the earth, by the ordinary pin and glass, the glass being inverted and kept filled with paraffin oil. On the scantling are placed large porcelain insulators, four for each cell—on which the cells are set—the cells are kept one inch apart, so as to allow a free circulation of air around the boxes which keeps them dry. As the tops of all the boxes are on the same level, and about three feet from the floor, they can be easily examined. A reliable volt-meter and hydrometer should be provided so that each cell can be tested every day or two, to discover if any one is becoming faulty. Sometimes a square of active material will drop out, and lodge on the positive and negative plates, making a circuit of comparatively high

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resistance between the two, which will in time completely discharge the cell. A test with a volt-meter will indicate a fall of potential, and the hydrometer will show a fall in the strength of the acid solution in a cell so troubled, and the cause may be removed in a few moments. A fault of this kind will probably be understood when it is explained that the plates of a secondary battery contract when being charged, and expand while being discharged.

If the correct strength of solution has been used when the battery is first set up, a good hydrometer will also indicate the amount of current that has been taken out, which should not exceed 85 per cent. of the capacity.

Right here I would remark that within certain limits it is impossible to overcharge a battery—but it can be completely destroyed in a very short time by over-discharging. During discharge sulphate of lead is formed, and that is the destroying agent in secondary batteries.

In conclusion, I wish to emphasize the assertion that secondary batteries have passed beyond the experimental stage. They must, however, be properly constructed; they must also have a capacity proportionate to the work they are intended to do. Such a battery can be placed in the hands of any one of ordinary intelligence, who, if he follows instructions and will give it the same amount of attention required by mechanism doing the same quantity of work, will meet with little or no trouble; on the contrary, the battery will be found always ready to furnish current at its maximum potential.

THE PRESIDENT: During a recent visit to England I found that the introduction of secondary batteries had apparently progressed a good deal beyond anything we had in this country, as far as I knew. There were a good many installations working in various places, in factories, houses, one place and another, and so far as I could learn, on inquiry, with very good success as a rule. I was somewhat surprised to find they were doing so much, better than we had been able to do in this country, so far as I could learn. But Mr. Bauer's paper informs us that he is getting results that are equal to anything that I have heard of or seen anywhere. It simply shows that if proper care and attention are devoted to the question that the secondary battery is a practical and commercial institution.

MR. MAILLOUX: I have been through the storage battery

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pretty thoroughly, and I have been through several phases of opinion regarding it. When it first came out I was enthusiastic about it, the same as was nearly everybody else. After a while my enthusiasm cooled, because I was connected with it practically, and I found that it worked a good deal better on paper than practically. Perhaps for a year I almost totally lost my faith in the storage battery. But as the subject received the attention of proper talent, and as the causes of its imperfections were investigated, I have begun to see my way a little more clearly into the possible success of it, and I have begun to feel a little more kindly toward the storage battery, and although I had another relapse from my good standing, I may say that now I believe the storage battery has come to stay. I believe that we are going to see the storage battery in this country assume a more interesting and a more important part in installations in which eiectricity is used. As the paper shows, nearly all the difficulties which have been considered as inherent in it, and not the least one of those is the formation of the sulphate of copper, have been overcome, and when we have got the storage battery as we have it now, so that power can be stored in it and be allowed to remain stored for a long time, as much as five or six months, then I believe we have got a practical thing; I do not think there can be any longer any doubt, as there are batteries which are accomplishing that, and they are being used with a great deal of success, so I believe that it is about time that we should undergo a change of opinion and think a little more kindly of the storage battery.

Mr. Shelbourne: I think it would be interesting to know from members of this Institute the business condition of this storage battery. If I recollect right I think Mr. Preece, during the fall of 1884, at the Philadelphia Exhibition, threw out an idea something of this sort—he rather scouted at the idea of there being a patent security upon the original storage battery, as I understood. What I am asking is, can the president or any one inform us as to whether there is one basic patent on the storage batteries in this country? I am informed that the Brush company has gone into that subject very extensively, and here we have a paper from Mr. Bauer of Baltimore. I was aware at the time of that battery being brought over by Mr. Bauer, because a friend of mine who was acquainted with him was on the same steamer coming back. I have seen so many claims about this one or that

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one promoting some storage battery in one section of the country or another, that I think it would be desirable to know whether there is any one source from which they originated, and whether that source is secured by a patent.

THE PRESIDENT: I do not know whether I can give any specific information on that point. The original storage battery is that of Planté, and there is no patent on that now in this country, and I do not think there ever has been. The improvement that was made by Faure was in the application of the substance to the plates, and that, I think, was the subject of an interference in the Patent Office which was awarded to Mr. Brush. I may be wrong about this; I have never given the subject any particular attention. It is possible Mr. Fowler may be able to give us some information on it.

MR. FOWLER: I am sorry to say that the secondary battery is a subject I have had very little to do with.

MR. MAILLOUX: I think you are right, Mr. President. There was a long controversy waged between several contending parties, and I was brought in as expert in favor of one of the contestants. It occupied several years, and there were some four or five inventors in this country interested. There were at least three or four who were interested in the suit, and the issue was, I believe, on the right to apply some salt or compound of lead in a disseminated form, as distinguished from the battery of Planté, in which the pure sheets of lead are used and a spongy formation is made by the current itself. In the Faure battery we also find that the oxide is made separately, or else that spongy lead is prepared and applied to that sheet of lead, which is so arranged that it has retaining cavities which will hold it. I have not had anything to do with the suit for nearly two years, but I have understood through the papers that Brush had come out first in the interference, and that a claim had been granted to him covering broadly the extraneous application of lead and lead compounds to a piece of lead forming the plate. In other words, I should understand that to mean, that although it is open for anybody to make storage batteries by using pieces of pure lead and forming them directly, that anybody who attempts to make a storage battery by taking lead plates and applying any mixture of lead to them is liable to infringe the patent.

THE PRESIDENT: That accords with my understanding of the position, which I did not present with any great confidence, because I thought I might be mistaken about it.

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MR. MAILLOUX: Mr. Wetzler here, of *The Electrical World*, could probably give some information about it, because I know something was said in that paper about it at the time.

MR. WETZLER: All I can say is that that patent was issued last January or February, and the essential point covered by it was the mechanical application of an actual material to the lead plate of the storage battery.

THE PRESIDENT: Then it would seem that the modern storage battery is controlled by that patent. You will perhaps remember that Mr. Preece, at the Franklin Institute exhibition at Philadelphia gave an account of a private plant of his own which he used to light his house, worked by a storage battery and a gas engine. I was at his house in February and examined that plant, and it was working very satisfactorily indeed with the same battery with which it was originally set up. But while I was there he changed it, not because the battery had given out, but because he wanted to enter on a new series of experiments with another make of battery, and so he took down the one he had been using from the beginning and took it to the Central Telegraph Station in London, and fitted it up for working a telegraph line, and he has just started on a new battery at his house. Mr. Preece is making tests two or three times a day, and keeping a very careful record of the performance of the battery, which will ultimately form the subject of a paper I have no doubt, and will be of very great importance in the way of giving information as to what results are obtained and what are the causes of them.

MR. MAILLOUX: There is one point that comes to my mind in connection with the paper of Mr. Bauer, and that is regarding the use of a hydrometer as an indication of the strength of solutions. I know very well that scarcely any well-regulated establishment is without a hydrometer, but unless they have had better success with it than I have, I do not think that its use is to be recommended. I do not think that the hydrometer is a very sure indication. It is a sort of guess-work, but I do not think that as an instrument of precision it ranks very well as a means of estimating the strength of a solution. While I was at work, particularly with copper solutions in Chicago during the last year, I was led to abandon its use entirely. To give you an idea of my experience in that respect, I have made say two different solutions that would both indicate about twenty-four degrees Beaume, and yet one solution would have a specific gravity

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about ten times greater than the other. The point was merely this, that in one case you had the same density in both—but in one case a part of that density was due to the presence of free acid, and in the other case it was due to the presence of the salt dissolved in greater quantity, and although they both had the same density, yet so far as their efficiency was concerned, either from the standard of free acid contained or the standard of resistance, they were totally unlike. So I found there was no reliance to be placed on it. I could not tell whether it was the kind of solution I wanted, though it might give the proper indication, and I found that the only reliable way was the acidometric test, by some means of estimating the amount of acid and the amount of salt in solution. That gave invariable results.

THE PRESIDENT: It would seem from what Mr. Mailloux says that the hydrometer should be relegated to the same region as the voltameter and many other of our cherished delusions.

MR. MAYNARD: I would not undertake to say anything about what the patent rights on this question are, but judging from the number of inventors about Washington, I should think the woods were full of them, very much as in the case of the telephone. Before the question is settled there probably will be a good many persons to be heard from. I happened to see the first of the experiments Mr. Bauer reports there in running street cars. The trouble was he had so much power that he ran the car and all the passengers off the track at the first move. That was owing to the putting on of too much power, and having an extraordinarily bad track to run on, heavy grade with sharp curves, and all the disadvantages combined.

About the length of time this battery would stand—I did some experimenting with some of these first batteries Mr. Bauer speaks of; not the imported ones, but some made immediately afterward, and made about as badly as they could be, and in a general way the experiments showed clearly that the electrical part of the thing was entirely feasible, and that after experimenting with this for about a year I had occasion to move the cells from the building where they were, and to stop the experiments. I left five or six of the cells which appeared to be the best ones, and they stood about four months in a damp cellar, and at the end of that time we had to capsize them, and they seemed to be about as good as ever they were.

MR. FOWLER: While I don't know very much about the

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foundation patents, I know there are about a dozen cases in the Patent Office now, just on the question of secondary batteries. Whether any have this foundation claim in them I am not informed. I know there are about a dozen cases of interference in this one matter.

MR. SHELBOURNE: As I understand it, Mr. President, such a battery as Preece is using now in his house, I should think is the one that he described at Philadelphia in 1884. As I am informed, such a battery as that may be used in this country without reference to any patent. It is one that everybody can use. This interference that was decided in favor of Brush, I understand, is for the mechanical application of an active agent to the lead plate. As I understand, Mr. Preece's battery was composed of lead plates themselves of a certain construction—spongy condition, or something of that kind.

THE PRESIDENT: The battery which Mr. Preece talked about was one thing and the one he uses is another. He uses the battery of the Electric Power and Storage Company; I think that is the name of it. That is one form. The other form is one made by Parker of Birmingham. I think they are under the same patent, but there is some difference in them. Both are made by the application of this salt of lead to the plate, and not accord.ng to the original form of Planté.

MR. MAILLOUX: If that patent is construed to mean the mechanical application of active material to the lead plate, I do not think it is essentially a very broad patent. But there is another way of applying lead to a plate, and it was in that way I made the first storage batteries I was called upon to make, that is, the electrolytic application; by taking a plate of lead and depositing lead upon it in a spongy form by electrolytic action. The originator of that idea was undoubtedly Mr. Keith, formerly Secretary of this association, and he conceived the idea in connection with his process for refining lead. At any rate, the first batteries that he produced were made in that particular way by taking plates of lead, perforating them suspending them in a solution and depositing lead upon them electrolytically. I doubt very much whether the Brush patent simply confines itself to that, because I know this point was gone over very fully in the evidence brought before the Interference Commission, and I have no doubt they made very strenuous efforts to cover that part of it. It is indisputable that you can make excellent storage

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batteries that way, so that unless the patent does cover that mode of doing it, it is not without a loop hole, at any rate.

THE PRESIDENT: I don't know that I ever looked at the patent carefully, and I cannot say whether it covers merely the mechanical application of the material, or the application of it in any way. It might well cover the application of it in any way if he was the first to do it, and in connection with this subject I might say that some years ago I came across a very excellent description of the storage battery in a patent by a Mr. Charles Kirchof of Newark. I think it must be twenty or twenty-five years ago that it was granted. I have not had occasion to look at it lately, but it struck me it anticipated a good deal of what has been done since. Possibly Mr. Fowler may remember it.

MR. MAILLOUX: Mr. Kintner has recently read a paper before the Franklin Institute, where he refers to that fact, and mentions the great importance of that Kirchof patent, which appears to have been entirely overlooked. It seems to cover many points since brought out as original.

MR. WETZLER: I received that patent from Washington the other day, and was much astonished to see, as Mr. Mailloux says and Mr. Kintner pointed out, that many ideas are in that that appear to anticipate more recent inventions. For instance he perforates his plates. He ruffles them also by pressing them between sand-paper, and he uses other means of that sort. It is a very interesting document. He uses the usual Planté process of formation, as it is called.

THE PRESIDENT: Is there any one present who knows anything about the history of this Mr. Kirchof of Newark? I am quite suprised at the fertility of the man's mind. He was one of the old pioneer inventors, and the germs of a great many modern inventions are found in his work. In looking it over I found at different times a good many things that have since developed into matters of importance. I think one of the first unisons for bringing step-by-step instruments into synchronism was in one of his patents. Then we find quite a perfect form of the multiple call-box, for sending a variety of signals from one box, and various other things of that sort. He was quite a remarkable man for the time in which he lived, and I have never happened to learn anything about him, as to who he was and what his history was.

MR. MAILLOUX: I think I know a little about it, because I am

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acquainted with his son. Mr. Kirchof originally came from Germany; he was a man of excellent education, being a graduate of one of the universities there, and I think he is now a translator of languages. Mr. Charles Kirchof, who, I think, is his son, was editor of the *Engineering and Mining Journal* for a number of years, and is now on the editorial staff of the *Iron Age*. I think that is his name. I think Mr. Kirchof lived in San Francisco at one time, and he has done a good deal in mining as well as in other scientific matters. I have read of him a great deal, and he is known to be a very well-informed scientist. I think he is also related to the discoverer of Kirchof's so-called Laws of Electrical Currents.

MR. WETZLER: I wish to rise in order to contradict the statement that Mr. Mailloux makes. I was acquainted personally with the gentleman that he speaks of and with his son, but that was not the Kirchof the President inquires about. The original Kirchof is dead. I happen to be acquainted with his widow, and I have often looked over his old instruments and books. It may not be uninteresting to note that he made a number of inventions outside of electricity. Among other things he invented a device for attaching candles to the Christmas trees, and his widow supports herself by manufacturing those articles now.

THE PRESIDENT: I think it would be an excellent thing for some one who has the material accessible to prepare a sketch of that man's life and works. He is a man who deserves to be better known to the profession.

MR. MAILLOUX: Mr. Wetzler is the man.

THE PRESIDENT: Mr. Wetzler I hope will be able to do it. I hope he will be able to give us a paper on it. Nothing is more interesting than biographical sketches of some of our pioneers in these matters. I think sometimes, as the saying is, some of them have forgotten more than ever we knew. Take such men as Professor Henry and Moses G. Farmer, very little of the work they have actually done has ever been published or made known. There are a good many other men in the same category. Some of their names even are unknown to the present generation of electricians, and it would be a good work for any member of this society who is enabled to get hold of any information of that kind to bring it forward and get it into our records and have it preserved. Those men did valuable work, and they ought not to be forgotten.

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MR. SHELBOURNE: I hope Mr. Wetzler will be able to introduce a picture of the gentleman in the *Electrical World*, so that we may know how he looked as well as what he said, because I think it is quite an important addition to what people say, to know how they looked.

MR. WETZLER: I will say that I am well acquainted with his widow, and she has given me access to his books, and if I can go about it, I shall do so at the earliest possible moment.

THE PRESIDENT: I sincerely hope you will improve your opportunities.

If we have no further discussion on this paper, I would ask if the Committee are ready to report on the subject of wire gauge.

MR. MAILLOUX: The Committee has met together and discussed the subject, and gone over the ground with the assistance of Mr. Pope, who has all the material, and has formulated the following resolution by way of report:

"*Resolved:* That the Standard Wire Gauge adopted by the English Board of Trade, be and is hereby approved, and that the American Institute of Electrical Engineers recommends its adoption for the following reasons:

1. It is desirable to secure uniformity in standard measurements wherever possible.
2. That the adoption of the S. G. W. is an important step in the direction of such uniformity.
3. It has been legalized and passed into current use in Great Britain and the colonies, France and Germany.
4. It is arranged so as to equalize as much as practicable the want of uniform gradation between sizes as found in other gauges."
5. It has a range in sizes which appears to comprise the extremes of large and small sizes likely to be used."

MR. MAILLOUX: And we might add the further reason that it has received the sanction of the other associations, the National Telephone Exchange and the National Electric Light Association, and that several manufacturers in this country have manifested their willingness to go by it altogether if it is accepted.

CAPT. MICHAELIS: This is a very important subject, and it is one, I think, we ought to hasten slowly about. This is an attempt to get an exact standard of measurement. It not only applies to the wire gauge, but it applies to everything else. The wire

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gauge is used for all sheet metals, and we know how they vary it. We work under the Stubbs, the old Birmingham, the new British, the Roeblings', the Pratt and Whitney, and I suppose there is no doubt there is a demand that there should be some one gauge which could be easily introduced and could be used as a standard. I think this Institute should do its share and exert its influence to bring about its establishment. I think the simple passing of a resolution like this would hardly have the effect that perhaps a more mature discussion with kindred societies, such as the Civil Engineers, the Mechanical Engineers and other institutions of that kind would have, and I have no doubt those other societies would cordially join with us to bring about on the question of guages exactly what the Franklin Institute some twenty-five years ago did in regard to the establishment of standard screw threads, etc., and I would suggest whether it would not be advisable that this matter be referred to the Council, or that a committee be appointed, or this committee be continued, with authority to consult with committees of other societies who might be invited to appoint committees to act with it. It has been done in other matters in regard to the formation of a common library, and I have no doubt the other societies would cordially unite with the Institute in attempting to bring about a standard gauge. I suppose the best way to obtain that is by governmental influence. I know that in government work we have been compelled to do away with naming sizes; for instance, in the inspection of rings for guns. We make rings. We call one a maximum ring and the other a minimum ring and furnish a rod, and say that is the standard rod for the maximum ring, and that is the standard rod for the minimum ring. I merely throw out these remarks as a suggestion. I think it is a very important matter, and I think the Institute ought to use its influence in bringing about a standard gauge of measurement, not limiting it to wire.

MR. MAILLOUX: I very heartily concur with the remarks made by the gentleman, and I do believe that we ought not to have one gauge for sheet iron, another gauge for sheet copper, another gauge for copper wire, and another for telegraph wire, as we have been having; yet, if there is anything to be gained by delaying action on it, I should be in favor of delay. At the same time, it strikes me that as the other electrical associations have already concurred in the use of this gauge, and adopted it officially, that

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our delay could not make much difference in the electrical part of it. We might let the report of the committee go over until some time later, and meanwhile see if we could secure concerted action with the other societies; but it strikes me there would be a great deal of time lost in the operation, and we do not expect that our decision will be final. We do not expect we are going to stipulate what gauge shall be used through the land, but we have taken one step, that is to affiliate with other societies who have adopted the gauge.

CAPT. MICHAELIS: I noticed that the last edition of Nystrom's handbook gives what is called the new British gauge. He gives it in inches. The committee report that it is used in France. I would like to know whether it has been translated to metrical measurements there and what valuation has been given to the metre. That is one of the mooted questions now. I think the value of a metre is hardly yet determined.

THE PRESIDENT: They have got nearer to it than you can draw wire I guess.

CAPT. MICHAELIS: I know. But I want to know whether the French scientists make any attempt to reduce this gauge—whether they attempted to deduce it originally on the same process determined on in England, or whether they simply translated the English measures into millimetres or centimetres.

MR. MAILLOUX: If I understand right, they simply translated it.

THE PRESIDENT: If I understand it, the original construction of the gauge by the English had some relation to an empirical basis.

MR. SHELBOURNE: It seems to me that the argument that was advanced here by somebody, that because the different European governments have adopted this standard gauge, and because the National Electric Light Association and the National Telephone Exchange Association have adopted it, that therefore this Institute ought to adopt it at once, else we would appear to merely fall in and adopt something that is already in use, is not an argument that ought to be given much weight. If we fall in and adopt this standard gauge at once, it certainly will appear in the reports of our action that we have adopted it as a matter of course, and without any concerted action with other societies, and without any elaborate consideration of its merits *per se* among ourselves, and as coming to the same conclusion as the results or our own judg-

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ment. Now, I have no doubt but that it would be advisable to adopt it in the end, but I think this Institute would get more credit by holding the matter under discussion and consideration than it would by just falling in *pro forma* with the opinions or decisions of the other institutes and associations that have adopted it. It has always seemed to me from the very first time that I came to consider wire gauges, to be a matter that was wrong end foremost; there did not seem to be any basis of reason in the way these gauges were arranged. Now, why should they have a lot of naughts, one or two or three or four naughts put down at the end of a gauge to indicate the largest sizes? I suppose it is because they started at one, and when they wanted larger sizes than that, they went down and indicated the other way. Now, why is it not in accordance with our ordinary ways of thinking and the ordinary notation of things in mathematics to go the other way, to reverse the system entirely? Why say No. 42 for the very finest wire, or why say No. 20 for another wire, or why say No. 16 or No. 12 or No. 8 for a larger wire? Why not put this thing in the relation of thousandths of an inch, and turn the scale end for end? If you want to commence with a fine wire, commence with as many naughts as you choose. But suppose a scale was arranged on the basis of thousandths of an inch, and we wanted to give them numbers. Now, if we make a gauge of which the highest number will be a half-inch in diameter, that would be represented by five hundred-thousandths of an inch. Now, suppose we commence at 1, and the finished wire would be one-thousandth, the next size would be two-thousandths of an inch, and the next size three-thousandths, and go on in that way up to five—up to ten, if you like. But where you get to the medium sizes, where such a little difference in diameter makes such an appreciable difference in the circular section, make the steps at five-thousandths. Then what will we have? We will have a gauge that will be composed of 105 divisions or steps, of 105 different numbers. First, there will be 1, 2, 3, 4, 5. There would in those sizes perhaps be too much difference between five-thousandths and ten-thousandths; you might make other divisions up to ten, if you choose, but you would get then the finest wire perhaps that would be practicably useful at a thousandth of an inch. A finer wire than that might be called hair wire. You would get the largest wire a half-inch in diameter, and when you go above that you might call them rods or bars. I do not put that down as an exact description, but

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upon some such basis as that we would get a gauge that would conform to rational ideas of numerical notations and sizes.

THE SECRETARY: I am not a believer in the policy of undertaking a thing of this kind and ignoring what has been done before and done very carefully, and going to work and doing it all over again just for the sake of saying we have considered the subject. This is a subject that requires very deep investigation in order to do it very thoroughly, and if we undertake to do that we have a pretty good contract before us. We have the records of what has been done, and we have the calculations elaborately worked out, and we can get all the testimony in regard to this matter that has been brought up in England. It was not accessible to-day, but it is in existence, and I do not think that under the circumstances we could be accused of undue haste simply because we did not go into all these calculations and investigations ourselves. It would be a matter requiring considerable time and considerable money, and, judging from my experience in the working of committees, it would be very doubtful whether we arrived at any conclusion, and if we did, if we attempted to introduce a new gauge or opposed the adoption of a standard gauge that had already gone into universal use, we would simply be putting ourselves on record as undertaking to do something that it was utterly impossible for us to accomplish. The movement has started, and whatever else may happen, we shall eventually be obliged to fall into line. The train has started, and we may as well jump on. It appears to me that we will save time and save words by taking it for granted that these gentlemen who have investigated this subject have done it conscientiously, because they felt, just as some of these gentlemen do now, that it is a matter of importance and should be thoroughly investigated, and they have done it. They have done it probably in spite of the opposition of various manufacturers who have gauges of their own that they wished to stand by as a matter of sentiment, and where so much has been accomplished in the direction of reform, it appears to me, as has been well said before, that it is better to have one standard, even if that standard is not a perfect one, than to have half a dozen poor ones with perhaps one good one amongst them. It is the multiplicity of t e gauges that has been the great evil rather than the inaccuracy of any of them. There lies the merit of this movement to reduce the thing to one

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standard, and for that reason the action on the standard gauge has made what progress it has made, simply because people want to do away with that multiplicity of gauges and get the thing down to one standard.

CAPT. MICHAELIS: Some years ago Brown and Sharpe promulgated, if I may use the term, what is known as the Standard American gauge, which was an attempt to soften the asperities of the Birmingham gauge, and to give the gauge a geometrical foundation. I have not heard what the objections were to it. I know it is not generally used by wire manufacturers, and yet wire manufacturers will use any gauge. I heard probably the most distinguished wire manufacturer in this country say that he would draw wire to any gauge he is asked to draw it to and paid to draw it to. If we are to have any gauge, it seems to me we ought to have a gauge founded on some reproducible mathematical basis. I would like to see a gauge from which, giving the size of No. 31, I could deduce the size of No. 30. You cannot do that from the Birmingham gauge, and with the new English gauge you cannot do that, because there are hiatuses in the construction. I do not know what the foundation is. Mr. Mailloux and myself have just talked it over. I see no intrinsic objection to having a gauge that could be calculated by any one. The gauge ought to be so arranged that if you know the extremes you can reproduce the intermediate numbers. I do not object to the new English gauge at all, but it seems to me it is a very important matter to commit the Institute to. I think we ought to have a wider and broader expression of opinion in regard to the matter. It seems to me that the matter might be confided to the Council, or that this committee might be continued, and that whatever recommendation they came to, be submitted by letter ballot to members, instead of having a score of us decide the matter.

MR. MAILLOUX made a sketch upon the blackboard showing the basis of the construction of the English standard gauge.

CAPT. MICHAELIS: I think, if you adopt a new gauge, it should be one that is founded on some mathematical curve or law.

MR. MAILLOUX: I think, Mr. President, that Capt. Michaelis's idea of a gauge founded on some conic section curve has in it the elements of practicability. In other words, it seems to afford that width of range—that difference of range which is evidently desirable between the first part of the scale and the other

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part. At the beginning, at the lower part of the scale—at the first low numbers, we want a considerable difference between the various sizes. While at the small numbers of wire we want an exceedingly small difference, and it looks as though it might be possible to construct a curve—to reduce the equation of a curve even from the standard wire gauge. The standard wire gauge could be taken in hand and under proper treatment it might be made to conform to a curve having an equation.

CAPT. MICHAELIS: I recall an article now that I read in the *Electrician*, I think, in which the writer produced a formula by which, given the gauge number, you could get the size in mils. He plotted the gauge, and I suppose attempted to reconcile differences. That was in one of the older gauges, and then he did get a formula, introduced certain constants and found a method that approximately gave him the number of the gauge if he had the wire, or the diameter of the wire if he had the number of the gauge. If your gauge were founded on some mathematical curve, you could extend it to the minutest differences, because you can draw curves that will approach their asymptotes either rapidly or slowly. Knowing that curve, all you would have to do would be to substitute either the values of the ordinates or the diameters.

MR. MAILLOUX: It strikes me that the idea that is presented by this gentleman is very feasible, and al hough I was in favor of adopting the standard gauge through thick and thin, I think it would be well enough to wait awhile, and see if he or some one else could not suggest something that would be an improvement over the standard wire gauge. I think, at any rate, that the gauge, as now made, can be taken in hand and made to conform to what he suggests.

THE PRESIDENT: This brings us back to the original question, however, whether it is better to adopt a gauge that is theoretically imperfect, but seems likely to come into very extensive international use, or whether we shall adopt one that is in some respects better but which will leave us with two or three different kinds of gauges. It is a matter that I, myself, think ought not to be hastily decided, and I agree with Mr. Shelbourne, that it is perhaps of no very great consequence if we do not start with the procession.

MR. WETZLER: I move that the resolution be adopted.

The motion was seconded by the Secretary, who then read the resolution.

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A *viva voce* vote was taken, but the Chair, being unable to decide whether the ayes or the nays were in the majority, called for a division. Mr. Mailloux arose at this point and offered as an amendment to the motion of Mr. Wetzler that the report be put over until the June meeting. The amendment was accepted by Mr. Wetzler.

CAPT. MICHAELIS: Is there a June meeting?

THE SECRETARY: There is a June meeting of the Council.

CAPT. MICHAELIS: I would suggest that the subject be referred to the Council, with power to consult with other societies, and formulate an expression of the opinion of this Institute.

This was accepted as an amendment by Mr. Mailloux, and adopted.

MR. MAILLOUX: I would like to move that a committee of one, consisting of Capt. Michaelis, or, in other words, that Capt. Michaelis—

CAPT. MICHAELIS: I call the gentleman to order. He is interfering with the prerogatives of the President.

MR. MAILLOUX: That is all right. I move that a committee of one be appointed by the Chair. My object is—if I can state it before putting the motion—that I would like to see Capt. Michaelis present his ideas a little more fully in regard to means of improving the wire gauge or modifying it so as to make it mathematically elastic, so to speak. I think it would be well for a committee to be appointed to look into what can be done by way of improving the standard wire gauge. I do not think that it ought to take very long to go over that ground, and I think the committee might be able to bring in very valuable suggestions and put the matter in such a clear light that we might be practically in the way of putting before the public a gauge which would be so little different from the present gauge that it would not be met by much hostility.

CAPT. MICHAELIS: I second the resolution of the gentleman. I have been struck at this meeting with the fact that we have in the Chair a gentleman who is better versed in parliamentary rules than the majority of the presiding officers at any of these meetings, and with my abiding faith in his knowledge of parliamentary law, I unhesitatingly second the motion of the gentleman.

MR. SHELBOURNE: I desire to say in regard to that motion that it is not only unparliamentary but entirely out of order. By

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a motion that has been acted on, this matter was referred to the Council with power. Now, the motion of the gentleman is that a committee of one be appointed to bring into the meeting or to the Council some mathematical suggestions in regard to this thing. Capt. Michaelis is a member of the Council. Therefore, the value of Capt. Michaelis's suggestions here to-day will be apparent when the thing comes to be considered in the Council, and I think if there is any occasion to make a committee of one the Council will be able to do it.

MR. MAILLOUX: I must beg the Chair's pardon, and that of the meeting as well. It would appear that I know as little of parliamentary rules and proceedings as anybody. I was not aware that I was sinning against any rule. If I have, I beg pardon.

THE PRESIDENT: You cannot know less about them than the Chair, but it would seem, from a common sense point of view, that Mr. Shelbourne's point is well taken.

A MEMBER: There is lying, unacted upon, a resolution in regard to Past Presidents, and also in regard to monthly meetings.

THE PRESIDENT: I think the question regarding Past Presidents was settled, but the committee on the question of monthly meetings has not reported, I believe. We are ready to hear from them now.

The following was presented by the Secretary as the report of this committee:

"The committee on monthly meetings respectfully report that they consider such an arrangement desirable, and recommend that they be authorized to formulate a plan for such report, subject to the approval of the Council. In the judgment of the committee it would seem advisable that these monthly meetings be held at the same time and place as the Council meeting, and they would recommend that the next Council meeting, on the first Tuesday in June, be set as the date of this first meeting, at which the committee can then report on a more detailed plan.

G. M. PHELPS, Jr.,
C. O. MAILLOUX,
R. W. POPE."

"*Resolved:* That the committee on monthly meetings be and is hereby authorized to make arrangements for such gatherings as may be considered for the best interests of the Institute, and their action be reported to Council at its next meeting for approval."

MR. SHELBOURNE: Would it not be necessary, technically under the form of the resolution, that it be referred to the Council, and

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be made subject to their approval, because, if we authorize this committee to do certain things, and they report the thing to the Council, the Council would feel, you might say, instructed as to their duty by the vote that we now take. Is this matter subject to the Council's approval, or do we give it a final approval here?

THE PRESIDENT: As I understand it we give it approval here, and the Council are to decide on the particular manner of carrying it out.

CAPT. MICHAELIS: I happen to have an intimate knowledge of certain questions of the Constitution of the Institute, for the reason that I was present at the meeting when they were amended. I think it very well to have monthly meetings, but you can only reach them in one or two ways, without an amendment to the Constitution. They can only be held as special meetings, unless they be social gatherings and do not partake of the formal character of authorized meetings where business can be done. The Constitution provides that meetings may be called in two ways: by the Secretary on the written request of fifteen members; or the Council may call a special meeting. This committee can only make recommendations, and then either have a call signed by fifteen members of the Institute and presented to the Secretary, who would then call a special meeting, or they might recommend to the Council to call a special meeting at such a time as they saw fit, but that is the only way. This meeting cannot provide for the monthly meetings. In fact there cannot be monthly meetings until the Constitution is amended. There can only be special meetings called in the manner indicated. I do not desire to make any point about it at all, but only to state what the constitutional provisions are.

THE PRESIDENT: It would seem, if Capt. Michaelis is right, and I presume he is, that no particular action is needed about it; that the Council are quite competent to order these meetings if they think it desirable to do so. So, in that case, it would seem to be only necessary, as to our present action, to recommend that the Council do it.

MR. SHELBOURNE: That is the very point I wanted to raise. If you make this committee report subject to the approval of the Council, and not decide the approval here at this meeting so as to instruct the Council, but make it subject to the approval and in the discretion of the Council, then the Council can call these special meetings.

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THE SECRETARY: We were fully aware of this provision of the Constitution, and it was our intention to comply with the requirements in obtaining signatures, not only that, but to have a contract, as it were, from the required number agreeing to be there in order to make a meeting. This is merely an effort, I may say, on my part, to carry out the ideas suggested, and get something done when we are together to-day, instead of separating and not doing anything more for a year, perhaps.

CAPT. MICHAELIS: I think that is a capital idea, Mr. Secretary. Are there fifteen members here, or is there a majority of the Council here?

THE SECRETARY: There is a constitutional quorum of the Council here.

CAPT. MICHAELIS: When does the Council meet?

THE SECRETARY: The first Tuesday in June.

CAPT. MICHAELIS: Why should not that quorum of the Council now decide to call a meeting on the first of June, and give all here present notice that there will be such a special meeting.

MR. MAILLOUX: Can the question of Constitutional amendment be brought up at a special meeting?

THE SECRETARY: The rules may be amended at any regular meeting by a two-thirds vote of the members present, provided a written no ice of the proposed amendment shall be given at a previous meeting.

MR. MAILLOUX: And there cannot be any constitutional amendment made until next year.

THE SECRETARY: There are two other regular meetings to be held as appointed.

MR. MAILLOUX: But we cannot, under the Constitution, make an amendment until the thing has been proposed in writing.

MR. SHELBOURNE: This committee is not ready to formulate the details, and how can the Council act upon some thing which is inchoate, and as this meeting of the Council is to be in two weeks from now, which, as I understand, is the very first day of June, and we are now at the 18th of May, I do not see how, even if we could carry out the view of the Secretary or of the Committee, any action could be taken at the present time so as to have a special meeting at the same time and at the same place as the meeting of the Council on the first Tuesday in June. If they are to formulate a plan and report the details to the Council, then

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the plan cannot go into existence before the Council considers it, and that will be the first Tuesday in June. Then we are coming into the summer, and the question is, when can we have monthly meetings after that, whether approved by the Council or not, or whether called by the Council, or whether called by the Secretary upon the request of fifteen members. Of course I believe in these monthly meetings, and I believe in organizing them and carrying out that plan as soon as practicable. But we are just on the edge of summer, when everybody goes out of town, and people prefer to loll on verandas with palm-leaf fans in their hands to getting together in meetings. I think that if we are going to have undue haste in this matter, perhaps we will defeat the very object we are trying to promote.

THE SECRETARY: Mr. Shelbourne has brought up the very point in regard to it that I mentioned in my report, that is, that unless we have a meeting the first of June, it would be well to lay it over until autumn, and it was for that very purpose it was brought up, that we might have simply one in order to start it before summer, for fear that so long a time would intervene before the next one, that instead of undue haste we would have undue negligence, perhaps.

MR. SHELBOURNE: Let the Council now call a special meeting. They can do so.

MR. MAILLOUX: If they think there would not be time enough before the first of June they could call the special meeting for some other time in June.

CAPT. MICHAELIS: I am sorry to say that a meeting cannot possibly be held on the first of June, because the Constitution provides that at least twenty days notice must be given to every member.

THE SECRETARY: That is what the Constitution says, but I am sorry to say that it is not carried into effect, for if you send notice too far in advance membe s forget it, and consequently it has been the practice not to comply strictly with that provision. This is not a personal matter with me. I do not care anything about it at all personally. It is merely a matter for the good of the Institute. People ask me, and members ask each other, if the Institute is alive, and so on. These questions are coming up—here is this wire gauge question. We could talk all night on that, I suppose, if there were not any special business, and I feel very certain that it is important for the welfare of the Institute

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that something of this kind be done. But whether it is done now or whether it is done next year, it makes no difference to me. I simply recommend it for the good of the Institute. There will be less work for me if it is not done. I do not object to the work, but I want to arouse a little sympathy in its execution and feel an interest in it which I cannot do if we allow things to lie over for a year or six months. If we proceed in that way the Institute will drift along and nothing will be accomplished.

CAPT. MICHAELIS: I give notice now—I suppose it ought to be in writing, but perhaps the stenographer's notes will be taken as writing—I give notice now that at the next special meeting of the Institute to be called as provided in the Constitution, I propose to offer an amendment relative to more frequent meetings of the Institute, and also to define what business shall be done, and what powers shall be exercised at such meetings. I do that under the constitutional provision that these rules may be amended, provided that written notice of the proposed amendment shall be given at a previous meeting.

MR. SHELBOURNE: The question before the Institute is upon the adoption of the report of the committee, I believe.

THE PRESIDENT: Yes, I believe that is the question.

CAPT. MICHAELIS: I move that the report of the committee be accepted, and that the committee be continued.

A MEMBER: I think it will conduce to the life of the society and its best interests to have an informal meeting called. Let the Secretary send to the different members and get them together to discuss the feasibility of holding such meetings.

The motion to accept the report and continue the committee was carried.

THE SECRETARY: I will merely say, Mr. President, that in doing this we will endeavor to comply with the requirements of the by-laws.

CAPT. MICHAELIS: It is thought feasible to have another meeting before summer. Do you think we could get a large meeting in June?

THE SECRETARY: Not a large meeting.

CAPT. MICHAELIS: A representative meeting?

THE SECRETARY: Yes, a representative meeting here in New York.

CAPT. MICHAELIS: Then, I think it proper that the Council should call another meeting to be held in New York some time

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in June. If the gentlemen who know most about these affairs—the President and Secretary—deem it feasible to have a gathering that will be a representative one, I can see no objection to having the Council call some such meeting in June.

THE PRESIDENT: There is no apparent reason I can see why the Council should not call such a special meeting and hold it as early as possible in June.

CAPT. MICHAELIS: It would be a regular meeting at which amendments to the constitution could be considered.

MR. MAILLOUX: That is the object. The object is to have the society in such shape that it will be legal and proper for us to hold such monthly meetings, and we want to have the plan matured now before the society goes on any further, so that when we come together next fall we shall have a programme to follow out.

THE PRESIDENT: I do not know that that requires any special action. It is quite within the scope of the power of the Council. There are enough of them here who understand what is necessary to be done.

MR. SHELBOURNE: I don't think an informal meeting, Mr. President, can be called in a formal manner.

The meeting then adjourned.

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SUPPLEMENT.

At a dinner and special meeting of the Institute, held in the Mills' Building, 35 Wall Street, June 8th, 1886, among other proceedings the following discussion took place, on the subject of Mr. Shelbourne's paper read at the annual meeting of the Institute, May 19th, 1886.

The President, Mr. Frank L. Pope, in the chair.

Mr. Shelbourne, addressing the meeting, said:—

The matter which I have to present is rather an after affair. It is, perhaps, a supplement to what was said in my paper at the annual meeting; and the reason for it now is found in the fact that, since the annual meeting, there has been published in the *Electrical Engineer*, the concluding portion of the discussions in England, in the Society of Telegraph Engineers, upon the paper by Prof. Hughes, at the annual meeting of that society, when he took the chair as its newly elected President. I want to say preliminarily that what I have to present is written out in order to make it concise and in proper form, and that it is rather tentative. I have formed no definite views, because I have not had time enough to study the subject farther, nor have I obtained the opinion of any other person, except a friend of mine, on the subject. Therefore you may regard it as theory or something to advise me about, or something to think about.

I want to say that I am sorry that Mr. Lockwood and Mr. Seely were obliged to leave to catch the train, because I had hoped particularly that Mr. Lockwood would give us his views on the subject.

[The supplementary paper was as follows]:

Mr. Chairman and Gentlemen:—When my paper on underground electrical systems was read by Mr. Ryan, at the annual meeting on May 19th last, I took occasion to say that I thought the opinion or idea which had been promulgated and urged in

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several quarters, that iron pipes or conduits caused a retardation, more than other metals or materials, of the electrical currents in the conductors within them, was erroneous and based on no known facts or theories of static induction.

In that paper, I expressed the view that if there were any real differences observed, instead of being charged to the account of static induction, a solution for them might perhaps be found in theoretical considerations of dynamic reactions. I used the word "theoretical," because I did not know at that time of any researches or experiments to confirm my ideas as to the cause of such effects.

I have since observed, on reading the stenographer's report of the discussions on that paper, that Mr. Mailloux touched upon a theory of explanation which tallied in most every respect with the ideas I expressed.

It now affords me a more definite satisfaction to find what I believe to be a strong confirmation of my views, from actual researches and very careful experiments, and that too coming from a most eminent and reliable source.

We have just had printed, in the June number of the *Electrician*, a report of the concluding discussions in the English Society of Telegraph Engineers, upon the very important address or paper of Prof. Hughes on taking the chair as President of that Society. In those discussions, Lord Rayleigh intimated that most of the results of Prof. Hughes' experiments had been foreshadowed by Clerk Maxwell, which, although properly rebuked by Prof. Forbes, only shows to us plebeians on this side of the Atlantic, that even noble and scientific minds are not free from those ungenerous disturbances so familiar to lower toiling mortals.

It was after such observations by Lord Rayleigh, and the close of the verbal discussions in the Society, that the facts came out, of which I wish to speak, in the written reply of Prof. Hughes to those discussions.

The additional researches of Prof. Hughes, given to us in that reply, seem almost directly to confirm the theoretical views I have expressed in my paper. You are all aware that Prof. Hughes' experiments related to what he calls self-induction, or what are commonly known as extra currents in the single identical wire operated upon. Although ordinarily, when speaking of dynamic induction in the telephone, we mean the currents generated in

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other wires parallel to the one in operation, yet we may fairly recognize that self-induction, as treated of by Prof. Hughes, is nothing else than dynamic induction, more properly considered as dynamic reaction. And so we can see how it may come to have been thought that "retardation" was the right name to be given to the effect, alleged to be observed in telephone lines in iron pipes underground, as though these effects were correctly to be referred to static action.

Now Prof. Hughes' latest experiments have conclusively shown that the difference in the electro-motive force of the extra currents, induced in copper and iron wires of the same length and diameter, under identical conditions, is as 100 to 400 in favor of the copper; but when the copper wire is insulated and placed in a close fitting soft iron tube, the electro-motive force of the extra currents becomes greater than if the copper wire were an iron one; in other words, the electro-motive force of the extra currents in the copper wire is now as 450 to 433 for the iron. These results are to be referred of course to the variable periods of the current employed in the experiment.

Now, in the telephone, we have not only a constant and very rapid succession of variations, but a reversal of line current for each variation, and a dynamic reaction for each impulse in either direction. If now these dynamic reactions are greatly enlarged in electro-motive force, by the active and changing magnetic state of the soft iron very near to the insulation of the conductor, and this magnetic condition of the iron has to be taken on, discharged, and reverse charged, at every change and reversal in the telephone line current, we can see how the sluggishness of the reactions in the soft iron in enlarging the extra currents in the wire, or the self-induction of Prof. Hughes, will cause the sharp variations in the telephone current to be filled up and impeded, by the extra currents, so that the voice becomes, as it were, an attenuated and hollow echo. There would seem, from the similarity of effects, to be much excuse for mistaking such dynamic reactions for the well-known retardation resulting from static induction.

But here comes in the still unsettled question whether iron has inherent magnetism, and whether therefore the circular lines of force, emanating from the telephone conductor, can and do cause an active magnetic condition in the surrounding soft iron, so that the variations of that magnetic state, due to the changes in the

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telephone current, serve to produce the magnetic reactions by which the countervailing extra currents are enlarged to exert a baffling power?

The recent experiment of Prof. Hughes would seem to throw some light on this question in favor of inherent magnetism in the iron.

Mr. Carl Hering, of the Franklin Institute, says in an able paper on dynamic electricity, that "it is claimed by some that iron merely conducts and condenses magnetism, but has no inherent magnetism of its own. It is very doubtful whether this last statement is correct."

If we assume that iron is endowed with inherent magnetism, so that lines of force acting extraneously to their own source or material of production, instead of being only condensed and conducted through the iron, can set up an active magnetic state in it, then we can understand how the theory I have advanced of dynamic reactions in telephone conductors placed within soft iron pipes underground, can be readily illustrated as founded upon the changes in the magnetic state of the iron, produced by variable or intermittent currents in the conductors, within them. At any rate the valuable experiments of Prof. Hughes have opened the door to the more conclusive determination of this question, which certainly cannot be very long delayed.

I have assumed in this discussion that the contention of those who assert for an iron conduit an effect upon the wires not produced by other conduit metals to be well founded. But no proof has been offered, and the fact is far from being established on mere assertion; for, electricians of experience in testing underground wires, maintain that wooden boxes for conduits give the same effects and no worse or different ones than iron or other metals.

Yet, if the contention be true, it remains only to point out certain conclusions to be derived from the theory of dynamic reactions, when found to be supported upon further inquiry of facts.

The English Government have put down underground wires in small *wrought iron* tubes not over three inches in diameter. Of that size and sort too were the pipes put down in Boston by the American Bell Telephone Co. So also in this city, were the pipes for the telephone wires put down for the Metropolitan Telephone Co. by the Edison people, and so too in the so-called Brooks' oil "system."

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If instead of these small soft wrought iron tubes, large coarse and common cast iron pipes had been used, in which the iron contains more of carbon and impurities of silicon arsenic, phosphorus and others, and which is far less capable of the magnetic state, the difficulties of such magnetic and dynamic reactions would largely disappear, both because of the character of the material and from the greater distance in a large pipe conduit, through which such actions and reactions must proceed.

The companies in this city, and particularly the Commercial Cable Co., which put down six inch cast iron pipes, have found no trouble in telephone experiments, from such reactions.

Again, it will be seen that where, as in the underground system of the New York Electric Lines Co., the trunk lines for the telephone are put down in cables of strands of quadruple conductors, and the opposite conductors of the twisted strands form the limbs of a metallic circuit, to be operated with local subscribers ground circuits, by means of induction repeaters at the exchanges, no dynamic reaction can be produced exteriorly in the circuits of such strands, because, primarily, no magnetic state can be created in the iron of whatever character it may be, since each inductive telephonic impulse in the one limb of the circuit is counteracted by an equal one of an opposite tendency in the other limb of the same circuit, and thus, where the iron can get no magnetic conditions, it can be capable of no magnetic reactions.

Mr. Shelbourne, after reading his paper, continued as follows :—

Of course the question as to the proper recognition of the existence of the fact, if it be a fact, that an iron pipe exerts an influence deleterious to telephonic currents within that pipe, more than other metals, is an important one. We clearly understand that the iron or any other metal will allow the earth to get that near to the telephone circuit and those actions and reactions which are due to static induction will be just so closely proceeding to the telephone cable or wire as the iron or other metal will allow. That is clear. But if these effects are observed in iron pipes are they not due to dynamic reactions? In other words to those enlarged extra currents which have been shown by Prof. Hughes in his experiments; and if so due, are they due to an active magnetism in the iron or to an active magnetic state which, under the influence of the current, is taken on by the iron, and which reacts upon the current?

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Considerable discusion then took place, in which Mr. Mailloux, Mr. R. W. Pope, Mr. Moses, Mr. Hamilton, Mr. Shelbourne, and Mr. Rapieff took part.

The meeting then adjourned.

[The discussions were not reported at length by the stenographer.]

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OF THE

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OF

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VOL. IV.

MEETINGS OF JUNE 8TH AND DECEMBER 7TH, 1886; FEBRUARY 6TH, MARCH 15TH, MAY 18TH AND JUNE 28TH, 1887.

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INTRODUCTION.

The fourth volume of the Transactions of the American Institute of Electrical Engineers is the first that has been issued containing the papers presented at special meetings and the ensuing discussions. The rapidly extending field of electrical industry has developed a corresponding growth of scientific electrical research, and acting upon the supposition that beneficial results would follow a straightforward attempt to encourage the interchange of ideas upon the electrical questions of the hour, the Council has, during the past year, appointed more frequent meetings, the records of which are now published in full. The good effects of this policy have been manifest, not only in the steady numerical growth of membership, but in the widespread recognition of the scientific standing of the Institute as a body. Some of the most distinguished electrical engineers of the world have appeared before it, and the thoughts of its members have been stimulated to renewed activity by the information elicited during the various discussions which have taken place.

As has been previously announced, the full reports of meetings are to be hereafter published in separate numbers during the month in which such meetings are held. This will furnish a most desirable channel for the presentation of important electrical papers and their intelligent discussion, which is offered by no other society in America.

It will be the continual aim of the Council to use all possible means to further the objects of the Institute as outlined by its founders in 1884, namely: "to promote the arts and sciences connected with the production and utilization of electricity, and the welfare of those employed in these industries, by means of meetings for social intercourse, the reading and discussion of professional papers, and the circulation, by means of publications among its members and associates, of the information thus obtained."

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AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

Special Meeting.

Subject: INCANDESCENT LIGHTING FROM CENTRAL STATIONS.

June 8th, 1886.

The meeting was called to order at the Mills Building, 15 Broad Street, New York, by the President, Mr. Frank L. Pope, at 8 P. M., who announced the subject for discussion with the following remarks:

It gives me very much pleasure to see so large an attendance on this occasion, the first of our monthly meetings, and it affords us excellent encouragement as to what we may expect in the future. It is an old maxim that we should always attend to business before pleasure. I think we have put in an hour of good solid business, and I had hoped that we should next have the pleasure of listening to a paper on the subject of Incandescent Lighting from Central Stations, by Mr. H. M. Byllesby of the Westinghouse Electric Company; but Mr. Byllesby has unfortunately become entangled in a complication of business that has come up during the past few days, which has occupied his time so fully that he is unable to be present, and in order, therefore, that the meeting may not be disappointed, we have asked Dr. Otto A. Moses, to favor us with his presence this evening, and to make a few remarks on the same subject, with which he is, as you all know, very familiar. Dr. Moses has very kindly responded to our request at considerable inconvenience to himself, and will now open the discussion.

Dr. Moses:—Thanks, Mr. President and gentlemen, for your consideration and this kind reception. It is, indeed, a great surprise.

I am asked to say something about incandescent lighting from

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central stations. The subject is a vast one, and I do not know from which point to attack it. Its ramifications have extended so far that if I start to treat of any branch and follow it up, I am sure to be felt along the line by some one present. I do not know in which direction the majority would have me proceed, but since we are to have a general discussion on my remarks, it would be well to introduce a variety of topics each forming part of the central subject which is: Where are we to locate central stations for all kinds of electric distribution, and how is electric energy to be generated, stored, and expended in them?

The central station of to-day is a very large and cumbrous arrangement. There are many engines in rapid motion and exposed to many dangers of interruption. There is an air of gloom and anxiety on every face; the unseen tremendous power not always under control, which is consumed at uncertain times and at invisible points, may be made to react at any moment with destructive energy. A central station ought to be in such a position that no accident could possibly happen to it—earthquakes, of course, excepted. I would have a central station put somewhere, where the fuel would be at its cheapest, labor very cheap, space costing next to nothing, and where your supplies would be without fail. Imagine to yourselves a central station in this city, with a break in a water pipe leading to it, or a fire next door, and the rafters and bricks tumbling in on the boilers; or a gas explosion in the street, and a main electric feeder, supplying two-thirds of a district, bent and twisted into contact with an outer casing; imagine a hundred accidents that are likely to occur. Those things ought to be avoided; and for that reason I think we ought to say that henceforth our central station should be extra-mural; carry it as far away from the city as you can, into the region of the fuel supply, and when you have it there, you should be able to distribute power from that point to other cities than the one from which you carry the capital to build it with, analogously to what is done with natural gas and petroleum. Suppose, for instance, you should go out to some of these large waste coal heaps in the anthracite regions, and locate your central stations. The question then arises how are you going to get your current down conveniently? That is a point which I would like each one of you to seriously consider, and then to bring some fresh thoughts concerning it, to the next meeting. It is necessary that we should work out in various directions in solving this pro-

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blem. First we must have a means of storing electricity. Now don't laugh: it is absolutely necessary that we should have the means of storing electric energy after it is produced. That subject has fallen somewhat into ridicule, very much as did the incandescent light in 1878. People then looked askance at the great cumbersome lamps, with large carbons and blackened globes, and said to themselves, "there is nothing in this." But, during a period of a year or so, while no one seemed to pay any more attention to the subject, the incandescent light gradually evolved and under the glow of light shed upon us at this moment you see what it is to-day. So, I say, we must look then to the secondary battery again. There is no getting around it. I do not see any way of avoiding starting from a fixed point. Archimedes wanted a fixed point; we begin every geometrical demonstration from a point, and if I should wander from the point, please, Mr. President, call me to order. We have to go then to the source of supply for fuel and transform it into electrical energy and store it. We must have it where we can make it available. But for the present there must be an intermediate link forged in our chain in order to transform into electricity the sun heat stored up for future use in the coal. We have got to bring it into the form of potential energy, store it, and then distribute it. There is no trouble in the world in handling any Rhumkorff coil. Why, you would let your little child put on a Geissler tube and finger around it—not much danger there! It is a bugbear! People are scared at the handling of currents of enormous potentiality. I say, don't touch them; that is all. Let this current be as strong as you please, and it is harmless, if you don't touch it. Do you think I am going to tremble and gnash my teeth because I happen to know that there is a subterranean fire underneath us so hot that it makes a man shiver to think of it? Wait till it comes. Wait till we have a Cotopaxi or Chimborazo open on Long Island somewhere. Let us wait. I think I could count on my ten fingers the number of accidents that have occured thus far. And yet, like sweet morsels between their teeth the reportorial tongues roll these things about until every newspaper in the land speaks of death and desolation from electrical currents. That sort of thing, you know, makes a popular prejudice, and prejudices are always pandered to. But let us cut loose from prejudices. Let us go back then, I say, to the use of a very high potential,

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in order to economize in our conductors, and let us bring our electricity to some point where a careful man would handle it and distribute it without danger to the consumer. Do you think they would put a drunkard behind a bar to dispense liquor? Not a bit of it. So neither would a reckless or careless man be selected to superintend the distribution of great electrical currents. But we should cause the distribution to take place as closely as possible to the point of consumption; and I predict that the source of supply will be the coal bed itself. However, for that consummation we will wait a little while; I think I will be still grayer before it is effected. But it is not impossible even now. And, just there, I would like to call your attention to some points which I would have you carry away with you for reflection. If you take a gas flame and examine it you find something which to my mind's eye seems much like the vibrating carbon in this incandescent lamp. Chemically it is identically the same as that. I have analyzed them both. The temperature at which they are made is just about the same; and since their chemical composition is exactly the same, I ask wherein do they differ? They differ only in this, that the carbon of the lamp stays when you put your thumb on it; the other is like the Irishman's flea, although it gives light from the flame it is gone when you put your finger on it. Now, we have a current passing through that loop, and an electrical current is setting the carbon in violent motion—that is light. If I were to take a current shunt from that incandescent loop as you have all done, you would be able to measure the strength of it, peform various experiments with it, and the lamp might go on shining, even though you did take a shunt from it. Why, gentlemen, I ask in all earnestness, can't you take a shunt from a gas flame? There is something for you to chew on. You can get thermo-currents from a gas flame, as is well known, by heating in it joints of dissimilar metals. Those currents you may tell me, are produced by chemical action of these conductors at their points of contact—very easily said. But we don't see any very great disintegration of the metallic conductors, and we get comparatively large quantities of current, sufficent to deposit more than the weight of the metals at a distance, by chemical action. There is to be sure, the same source of energy there in both cases—that very convenient "heat" which covers a multitude of sins nowadays. Heat meets us as an answer at every turn. It is supposed to be the heat that generates the electricity in the thermo-current

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and it may be said because we can easily transform one force into another, therefore the heat in the case of the thermo-current generates electricity. Why, I can as readily ask, may not that thermo-current be the result of chemical action and heat combined? Is not chemical action there in that gas flame as the result of the heat? And why may not the source of electricity be the chemical action alone, and the heat be the effete electrical product? If you take two dissimilar metals and put them in the flame, one in the point of the flame and one in the interior, you get a current; but the action ceases very soon. You take joints at the end, and you get a continuous thermo-current there. What is the difficulty in the first case? Why can you not draw off quantities of current commensurate with the energy expended in the burning flame? Now here is the direction for you to look for new and startling results. You have got in the carbon of a gas flame a constant source of energy, and, if I may use the expression, a metal to be consumed. That carbon is consumed in the gas flame. There is a constant oxydation of the carbon going on. In the same way you consume your zinc in the battery by oxydation. Why have you not then, there, currents commensurate with the chemical processes that are going on? They must be there: they are there. Recollect the time that it took Faraday to discover his spark. It is very easy to find the spark now-a-days if you go around any central station for electric lighting. Now, then, this is the direction in which you have got to look for future sources of current, and it is in the coal field where we will have to make the transformation. Now, then, when you have got the combustion of carbon and oxygen, the carbon and oxygen being unlimited in supply, you have all that is necessary to produce current without end. If the combustion can be made to go on in the mine itself, you have got an endless source of electricity, without the necessity of gathering and transporting your supplies. Such currents may be of exceedingly low potential; but that is nothing. In the Bank of France to-day they are working arc lights from thermo-currents of low potential. There is no reason why thermo-currents cannot be used for extensive systems of collection and distribution, but, I say, generate your thermo-currents in the mines, where they will cost least to produce. Now, then, you have got to carry your thermo-currents from the mine, say, to New York. Well, to do that requires a current of very high potential. Now, in the present state of the

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art, to carry a current of high potential over the main wire, you must have good insulation, and the very best insulation for your dynamo machine, for, if sparks pass between the adjacent turns of wire, you have to unwind your dynamo machine to get at the damaged part. Some day you will be able to discard moving machines as a source of current electricity. What are you going to do with your dynamo machine in the mean time, you ask. I say for the present use your dynamo machines, but put them in the mines, right next to the coal. Burn your coal in the mine; build your boilers there. You need not carry your coal very far. Send your currents to the surface a distance of a few hundred or a thousand feet. Store your currents there. Now, for this use you can employ the simplest kind of dynamo machine in the world, furnishing currents of ½, 1, 2, 3, volts. What do you want with a current of a hundred volts in any dynamo machine. Carry your currents up to the surface with the lowest potentials, the largest conductors, the least resistance, and then store. Store what? Your surplus energy, keeping it at low potentials until needed, when, as in the thermo-pile, you may couple them up to 1,000—10,000 volts and bring your current into the city. Use, if you please, a Gaulard-Gibbs arrangement. Let that transform currents for you. What is the use of handling them? Take them off by induction. Here then, gentlemen, we have a brief sketch of a feasible method of bringing currents in unlimited quantity to central stations. First, burn coal, in the mines, make steam cheaply to drive large engines situated near at hand; these to turn dynamos of large size and producing currents of exceedingly low potential. Transform your currents at the surface. After their energy has been stored in secondary batteries you can couple them up to any potential you please. You can use your current when you please and as long as you please, or you may keep it stored. The loss is not more than from one to two per cent a day. That seems to me to be for the present an adequate method of obtaining a source of electrical supply of absolutely unlimited quantity. When you get it here you can redistribute it and retransform it. You will thus be able to generate electricity much cheaper than by bringing the fuel to produce it to the point of consumption, forcing it through large pipes, if it be natural gas, or flowing it through like petroleum, or carrying it as coal on railroad cars. Having brought you thus far, I will stop and let somebody else take up the current for distribution. (Applause.)

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DISCUSSION.

MR. WETZLER:—I would like to ask Dr. Moses what he considers the limit of potential which he would use in such a system?

DR. MOSES:—I would not hesitate to use 10,000 volts.

MR. WETZLER:—But you would want some one other than yourself to handle it.

DR. MOSES:—I meant that I would not hesitate to send a current of 10,000 volts but not to receive one. But, joking aside, if you insulate you can very successfully use small wires and obtain as perfect insulation as with a cable.

MR. WETZLER:—So your limit is 10,000 volts. I had occasion the other day to figure out a problem in which it was required to transmit 50,000 horse power to a distance of fifteen miles. I calculated that I would use 3,000 volts, and that the conductor would cost me over $5,000,000, since fifteen miles would require thirty miles of conductor, hither and thither. It requires about 16,000 amperes at 3,000 volts to give me 50,000 horse power. Allowing a loss of 33⅓ per cent. in transmission I had to have 50,000,000 volts.

MR. RAPIEFF:—Insulation of the 10,000 volts is not as easy a matter as you think.

DR. MOSES:—What very large Rhumkorff coils have we here in the city—about what potential—do you recollect?

MR. RAPIEFF:—I don't know; nobody knows.

A MEMBER:—Thirty thousand volts.

MR. RAPIEFF:—Is it difficult to get any insulator so perfect that there is no spark at all?

DR. MOSES:—Yes, although it is not the fiftieth of an inch in thickness.

MR. RAPIEFF:—May be not; but you must also take into consideration the distance in this case; that is the distance of the conductor from another conductor where the spark can pass, or else it is the greater distance between the spark and the free air.

DR. MOSES:—If there be no discontinuity, why should the spark pass?

MR. RAPIEFF:—Sometimes it is necessary.

DR. MOSES:—I do not see why it is necessary. As I say, I do not want to receive the current from a make-and-break arrangement. It is possible to make such machinery that there will be no necessity at all for the breaking.

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MR. RAPIEFF:—I do not say that it is impossible; but at the present moment I think that it is rather impracticable.

THE PRESIDENT:—It would seem that this question of the distribution of electricity is going to depend very largely on how high a potential we can use or can practically handle. I do not see why we should necessarily set that limit at 5,000 or even 10,000 volts, nor does there appear any good reason to suppose that we may not be able to handle 100,000 volts ten years from this time as easily as 1,000 to-day.

MR. RAPIEFF:—But suppose you look at the question from the present state of industry.

DR. MOSES:—When I called attention to the production of electricity simply from the coil I had no right perhaps to argue as I did; it was simply an hypothesis; but judging from the way in which you listened you seemed to think it possible and yet the transmission of considerable currents has not been accomplished, but the question is, may it not be possible at some early day to so insulate the conductors and isolate the currents so carefully that there may be no danger whatever.

THE PRESIDENT:—I think we should be surprised, if we knew how high an insulation we have already obtained in the Rhumkorff coil. A way was found to accomplish that; why may not a way be found also to effect the insulation hereafter in conductors carrying large currents of tremendously high potential? It was not until Ritchie, I think, invented the so-called Rhumkorff coil that the solution of the problem was found; it was not easy to find. Page did not succeed in making such a coil.

MR. WETZLER:—Well, Dr. Moses refers to some experiments made in France. They worked at 7,500 volts and yet they got a spark between the wires of their machines and ruined them. If 7,500 would do that, what would 10,000 do?

THE PRESIDENT:—It does not appear to me that it is a question of insulation of the machine, but of the insulation of the wire, and the machines must be eliminated from it and all fixtures of every description as far as possible.

MR. WETZLER:—Assuming that it is a question of insulation of the line wire, you have to consider the practical question of the cost of insulating such a line, when it would cost $5,000,000 for a copper line—just plain copper—at 12 cents a pound. I figured it a long while ago.

MR. SHELBOURNE:—If I understand the question, I think the

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induction apparatus was built by a gentleman in London—I believe that is the largest induction coil that has been built. It contained 150 or 160 miles of about No. 31 Birmingham gauge wire. In that coil the secondary is so put up that it can be divided into four parts or three parts; and the end wires are two sizes larger than those forming the middle portions, and as the wire comes to the end of the coil it is made larger so that the intensity of the current should not destroy the wire; it safely carries the current and then passes out from the coil through the insulated openings. I believe there are very effective means of insulating the wires, so that the current does not escape materially. The base is made of ebony or hard rubber.

THE PRESIDENT:—I am inclined to think that we shall depend very largely on air for the insulation of these high potential lines; and not attempt to put them underground, but suspend them on poles on a strip of land, a right of way which we will buy and own as a railway company does, and if any body goes on there, and trespasses or meddles, he is a dead man; he takes the risk.

MR. LOCKWOOD:—That is a good idea.

THE PRESIDENT:—A strip of land 100 feet wide for a right of way from here to Boston could easily be obtained. It is not necessary to follow any particular grade; you can go where you please through land of little value. You can keep trespassers absolutely off it, protecting it at the crossings, as you now protect a railroad. That has been a favorite idea of mine for a long time. Now when it comes to insulation, if you can cut out all trees and obstructions without interfering with anyone else, it is a simple problem. The air is a sufficiently perfect insulator, and hence it becomes practically a question of insulating the supports. All the leakage that occurs, takes place practically over the supports and very little, if any, through the air, no matter how foggy it is.

DR. MOSES:—Those currents however, being of exceedingly high potential, you might be compelled to insulate that wire and protect it from the rain.

MR. LOCKWOOD:—If I understand rightly, Mr. Wetzler's objections derived from the results he has come to after so much figuring, the chief obstacle to any such arrangement as Dr. Moses has suggested—and it must be remembered he suggested something to come hereafter—is the cost. Now, if such a state of affairs should occur, and I agree with Dr. Moses it doubtless will, I am

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not prepared to say how near in the future—the cost will be comparatively a trivial consideration—that is, the cost of carrying wire and the plant; in that, as in every other exploitation of electricity, the cost will ultimately fall upon the user. (Laughter.) I beg your pardon, gentleman, I did not intend to say anything funny at all, if you would hear me out, please. I was going to say, in that case, there would be a sufficiently large number of users to divide it up thoroughly.

THE PRESIDENT:—I might suggest that the cost in these enterprises sometimes falls on the stockholders rather than on the consumer.

MR. LOCKWOOD:—It would undoubtedly at first fall on the stockholders or bondholders; but the thing could be probably capitalized at the start, so as not to fall on the original bondholders or stockholders even; that might be well distributed.

MR. MAILLOUX:—Mr. Lockwood happens to be connected with a company which finds it practicable to make the user pay; but sometimes it is not practicable.

MR. LOCKWOOD:—I leave it to the gentlemen if the consumer is not the one who eventually pays for the electric light.

MR. MARTIN:—In that problem of carrying the power from Niagara, the cost figured out for the raw copper of the conductor, without insulation or anything else, sums up over $5,000,000. I believe Mr. Wetzler's figures are correct.

MR. WETZLER:—I was led to undertake the problem by a consideration that they were going to build a canal from Niagara to Lockport, and it struck me the thing might be done by electricity somewhat cheaper; but I concluded after figuring it out, that they had better build the canal.

THE PRESIDENT:—What we have to consider, is the comparative cost of carrying energy in its different forms, whether in the form of oil in the pipe; whether in the form of coal transported over a railroad, or in the form of compressed fluid carried in a pipe; or electricity in a wire.

Mr. MARTIN:—Well, we figured 3,000 volts. Sir Wm. Thomson tells us 80,000 can be used, and there is a wide difference. We took it at the practical figure of what we knew was being done at the present time.

Dr. MOSES:—Let us make a big jump then. I recollect, it is not more than five or six years ago when the carbons of incandescent lights had about two ohms of resistance, and somebody at

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a stride went up to about 200. Well, it was only a mere matter of degree. Now, while we are figuring on this thing, and we are going to use air insulated wires and going to have death lines, which I think is an admirable idea and will one of these days prevail; why not make a jump to 100,000 volts. All we have to do is to put the current on and take it off that wire by induction and not touch the wire while doing it.

A MEMBER:—There would be no difficulty if a line was left uninsulated provided the supports do not leak. You can carry a million volts; it would not inconvenience you in any wise. Why could'nt you use the total horse power of Niagara Falls instead of coal power?

Dr. MOSES:—You have simply to tunnel the falls above the rapids and put in turbines; then you have practically unlimited power.

MR. MAILLOUX:—If a system of induction coils were used one at each end, there would be a difficulty in regulating so as to keep the amount of the energy used proportionate to the amount of energy expended; in other words, to make the supply equal to the demand at all times. Now would we not comes across a difficulty with induction coils, similar to what has been met with in the machine of the Lontin type, for instance, which consumed more energy at the time they were opened than at the time they were closed?

THE PRESIDENT:—You will meet with exactly that difficulty. It is probably not an insuperable one, but it raises a very difficult question.

MR. MAILLOUX:—I think if we have a system of induction coils at either end, and then take the energy out again at the other end, as an induced current of lower potential and larger volume, we would necessarily meet with that difficulty, that as the amount of energy required would depend upon the amount used at the second secondary coil, then there would be no means of regulating that energy so that it would be always adequate. It strikes me I could conceive of a time when there would be more energy called for than the circuit would furnish, and at another time the circuit would be wasting energy, only a small portion of it being utilized, so that we are brought again to the storage battery pure and simple as Dr. Moses first spoke of it. It strikes me that we must have not only a means of transforming that energy but of storing it at the point where it is to be utilized because it can be stored

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against all sorts of contingencies. If not used to-day it will be to-morrow and the generator can be working constantly twenty-four hours a day, or as nearly so as possible, while we all know that we could not expect to have it consumed at that rate throughout. Consequently we will notice that energy transmitted at a smaller rate would be able to do heavier work because the time of charge can be so much longer and the charge is continuous.

DR. MOSES:—A storage battery could be devised that would do away with the ordinary secondary battery. If you are using currents of enormously high potential, you could use those currents for the decomposition of water. Here would come back one of those old prejudices. You recollect that with the first dynamo machine, as Mr. Dumont once told me—he told me the whole history of it—they wanted to decompose water, and, of course, they got over it by the use of light direct. But it is too expensive? In this case, where you have an unlimited supply, sacrifice what is necessary for the purpose and store your energy by using currents of enormously high potential and use it to decompose water which would compress itself almost to the liquefaction of the gas under currents of high potential.

MR. RAPIEFF:—Water is a very good conductor for currents of sufficiently high potential; but you would have to keep preparing distilled water.

DR. MOSES:—You could have energy enough in a barrel of water to run a city of 100,000 inhabitants—a barrel of absolutely pure water in a surrounding case, lined, if you please, with glass, or platinum, it would be possible to store your energy. Why not?

MR. RAPIEFF:—If you do not care for the expense, you can do anything, of course.

DR. MOSES:—The expense would not be so vast. All you have to do is to make your receptacle large enough and strong enough.

MR. MAILLOUX:—How would you utilize your energy stored?

DR. MOSES:—By combustion.

MR. MAILLOUX:—That would bring us back again to the gas secondary battery.

DR. MOSES:—That is so. Why not use the gas direct?

MR. MANSFIELD:—I was visiting a gentleman recently who related the following incident: The wire passing over the top of the batteries became disconnected resulting in a slight flash. There was a little overcharge and the gas accumulation on the top of

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his batteries exploded and the fright it gave that man convinced him of the financial possibility of the storage of considerable energy in that direction, and it is very strange that the same point should be brought up this evening.

DR. MOSES:—The gas battery is a very economical battery. Glass tubes are cheap and strong. There is no reason why you could not make an unlimited amount of them.

MR. SHELBOURNE:—Gentlemen, I have not figured out any of these problems, but a little common sense leads me to the belief—without saying that I have got an opinion—that the interest on $5,000,000 would buy and transport all the coal that was wanted for that horse power—the fifteen miles and put it down without any further expense.

MR. WETZLER:—Provided the coal was at the source, at that distance fifteen miles.

MR. SHELBOURNE:—True, but instead of bringing the currents of electricity wouldn't the interest upon the money required to build such an equipment, buy the coal and bring it here to New York city and then build the station in the outskirts or on a floating structure in New York harbor for your use?

THE PRESIDENT:—As far as the problem has been developed at present, of course it would. What we are trying to get at is to ascertain if there is any possibility of carrying our energy in the form of electricity more cheaply than we can do it any other way. We do not know how to do it yet. We hope to find out if we work at it long enough.

MR. LOCKWOOD:—Mr. President, it is quite well-known to us now, whatever it may have been before we met here, that lighting is the oldest profession in the world. Dr. Moses gave us that information.

DR. MOSES:—I was there.

MR. LOCKWOOD:—He said that the first words uttered were, "Let there be light." He now tells us that he was there, and, since matter is indestructible, there is no doubt that he was there—at least in the form of protoplasm. He proceeded then to make further remarks and quotations from a book I highly respect and before he said what he was going to say, I was under the impression that he was going to give as a reason for his presence here this evening, "And the Lord said unto Moses." It seems not. But to whatever beneficent spirit we owe the presence of Dr. Moses here to-night, I am sure you will all agree

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with me that we have been instructed and interested by what he had to say and we have the more reason therefore to congratulate him and ourselves in that his remarks seem to be entirely unpremeditated. He has given us great food for thought. I confess that I was unusually interested in his remarks and I propose to test them later, perhaps in the hope that I may be the fortunate one who may transform electrical energy direct from coal.

DR. MOSES:—I hope so.

MR. LOCKWOOD:—It seems to me that the thoughts of Dr. Moses and of every gentleman that has since spoken are, after all is said and done, much in the same spirit. He did not say, as I understand it, that the happy time that he referred to was now or next year or next century, but that it would surely be. Gentlemen who have spoken since, agree that the chief obstacle is expense. We all agree that things which are difficult are not necessarily things which are impossible. Thirty years ago many of the operations of electricity, which are now household words, were considered to be impossibilities. When Mr. Rapieff, who honors us with his presence this evening, first put his lamp in the *Times* office, he did not expect to sit with us at this board in a room lighted by means of this incandescent electric light. When Mr. Edison transformed the lower resistance cylinder into the higher resistance filament, he did not anticipate that within three or four years half a dozen other gentlemen would have anticipated him in that achievement and would all have been the first inventors of the high resistance filament, and I don't know, I confess myself, where the point of low resistance stops and the point of high resistance begins. But, perhaps, some of us may, and, therefore, I say that the remarks and opinions of every one that has spoken yet, seems to be very much in the same line, except in the degrees.

Now, speaking of secondary batteries. The gentleman who spoke last regarding secondary batteries, mentioned about the gases playing over the surface during the chemical operations of the battery; and it occurred to me that the flash he spoke of might have been the flash due to the operation of the electrodes at the time. I do not know that that is the case. I merely make the suggestion.

I was very much pleased also to hear Mr. Wetzler's statement as to expense. It shows that he looks at things from an economic point of view, and in their right light, and is not dazzled by the

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way that electricity frequently throws a glamour over all our eyes, so as to make the smallest things done by electricity seem great, easy and good. The late Cromwell Fleetwood Varley used to hold it as a maxim never to do anything by electricity that you could as well do by hand, and it is a first class maxim whether applied to telephony, telegraphy, or lighting. If we could make lights as excellent as these without going through the formality of dynamos and wires, it would be better, provided we could do it cheaper. But the maxim is good any way.

MR. MAILLOUX:—I would like to hear from Dr. Moses, as he is an authority on incandescent lamps, what his opinion is as to running incandescent lamps either with high or low potential.

DR. MOSES:—As far as the use of low resistance lamps is concerned I think that when you consider the cost of the conductors that for a series arrangement they are unsuited, so that I do not see any advantage in them whatever.

MR. LOCKWOOD:—But one will light a room fairly well if it has one of these two powers.

DR. MOSES:—It depends on the size of the room. But the difficulty about them is the machinery that is necessary. The problem that every inventor ought to set before himself, and he should repeat it after every thought, is: Can I simplify this thing? And when he gets it down to such a condition that it cannot be simplified any more, then it is perfect. You cannot have a simpler arrangement than a carbon loop; and when you have got that and a constant current, why must you interpolate machinery in it anywhere? Let the machinery do its own regulating and the lamp do its own regulating. You hear people frequently say, "Oh, if we had a lamp that we could turn down!" What is the use of that? In the day-time we don't think of turning out the sun, though we have a great deal more light than we need. Expend your ingenuity on devices by which you can have as much light as you want at any time. Now, as far as the use of incandescent lights on circuits is concerned, there is another problem that ought to be studied. It is very near solution, though, I think, now. You may hear more of it later. You can use currents of any potentials for running incandescent lamps. The same conditions hold as for running currents, as we were discussing a while ago. All you want is proper insulation. If you examine one of these lamps—I don't suppose Mr. Edison would object to my advertising his lamp a little more than I have done

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—(illustrating). If you examine that lamp, you will find right here is a metallic cap. Now if this was a current of about 10,000 volts and my shoes were wet and there was a leak on that line and I touched that cap, how far do you think that I would jump? —that is if I could jump? Now you see, that is a very ingenious arrangement, but it is also a very unsatisfactory arrangement if you use a lamp with a current of 1,000 or 2,000 volts—very inconvenient. Therefore, you do not see these lamps in series. You do not see them on currents of very high electro-motive force. Now that is a mere mechanical problem. It is a question that has not yet been touched on—series illumination. I could use a current of 100,000 volts—why not?—by a proper insulation. Mr. Edison does not choose to use a current of more than 110 volts, because he says when you are putting on and off lamps, there would be great danger in the use of a current of very high electro-motive force; but if you insulate properly and have no contact there for making and breaking the currents, there is no reason why you should not use a current of 5,000 volts on incandescent lamps. There is a nut for you, gentlemen, to crack.

Mr. Lockwood:—Isn't there one objection to high resistance incandescent lamps—the necessity which arises of using large mains? Otherwise you are just as likely to have an incandescent lamp of your leading wire, as you are of your lamp itself.

Mr. Mailloux: And using shunts.

Mr. Lockwood:—Yes.

Mr. Mailloux:—Isn't the three wire system equivalent to the serial system for all purposes?

Dr. Moses:—To a slight degree.

Mr. Mailloux:—Couldn't that be extended further?

Dr. Moses:—No, it wouldn't be advisable. You want as constant an electro-motive force as you can have, even on a three wire system.

Mr. Mailloux:—Couldn't the same arrangement be applied to ten wires, with a dynamo between each, and have ten lights in series in the circuit, and use ten times as high electro-motive force as you are using now?

Dr. Moses:—Still it wouldn't be so practical, where you are using more than two conductors, you are increasing the difficulties very much indeed.

Mr. Mailloux:—It occurred to me that in streets like those we have up town, parallel to each other, large conductors might

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be run on the two outside avenues; in the intermediate avenues we could run small conductors; then have them all branch through from each other by means of wires, running through the numbered streets, as may be necessary and those wires to be used only for equalizing the difference of potential between those blocks. It occurred to me that in this way you might use a higher potential with a small amount of copper perhaps. I don't believe myself that the figures will show as large an economy for the three wire system as has been claimed. Yet, at the same time, I recognize that the system might be made to give a larger saving and that smaller conductors could be used than where you have to run a parallel or multiple system all through.

DR. MOSES:—That is so; it would be worth trying. Even with these currents they do not regulate themselves; that is all done by hand.

THE PRESIDENT:—I would like to ask Dr. Moses if it is not the case that the larger the number of lamps in the system the less trouble regulating it by hand—the less the particular attention of the engineer or any other person who has charge of it is needed; in other words, doesn't the larger number tend to make the changes in the consumption of current very gradual?

DR. MOSES:—Yes, that is true; and once you get your brushes working well, and avoid any of these effects Mr. Hughes speaks of in his recent paper, you work along very nicely; but if some careless man skips a brush and gets on the wrong block, and gets some of these extra currents in, all that tends to disturb things, so that it is all very good when you have three wires, but it is very complicated with four; it has got to be very nicely balanced.

MR. MAILLOUX:—Would it be practicable at present to make them so as to work with high potential—say two or three hundred volts?

DR. MOSES:—Yes, you can make incandescent lamps to run at 500 to 1,000 volts. You see the limit is this—the length of the incandescent conductor.

THE PRESIDENT:—There is now working in London a pretty large installation of incandescent lamps in the establishment of Whitely, "the universal provider," which is worked direct by an alternating dynamo—I think it is a Ferranti. I was told, when in London, a few months ago, by some of the electricians there, that the result in that establishment had tended to show that the life of the lamps was longer under an alternating current than with a direct current.

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MR. RAPIEFF:—The experiments of Siemens also proves that alternating currents are better for the life of the incandescent filament, but I don't think it is correct.

THE PRESIDENT:—You have perhaps noticed that the same claim is made at the establishment of Ganz and Co., electricians in Buda-Pesth. Mr. Deri has stated in an article which I have seen in some paper, that they have established that fact by their experiments; but then it is to be remembered, of course, that they are interested in exploiting an alternating system, and it is their business to make the advantage appear if they can.

MR. MAILLOUX:—If we can consider the filament of an incandescent lamp as an electrolyte, it would seem as though an alternating current would have less disintegrating effect; for it is well known that with an electrolyte subject to decomposition, an alternating current does not have any effect, where as with a continuous current it would have some tendency to exhibit migration of the ions in either direction. It would appear to me more rational to describe the deterioration of the incandescent lamp to a continuous current, and a *posteriori*, it would show that Dr. Moses's view of the filament of an electric lamp was correct.

DR. MOSES:—You may be interested in the following facts: When the first incandescent lamps were made they had been in existence from 50 to 100 hours. I do not think there was any one of them that had lasted more than 100 hours, and they commenced to go off. Well, Mr. Crookes—because these things traveled very rapidly by telegraph at that time—he advanced a theory—which is now known as "the Crookes effect," that there was a chemical decomposition that took place; first a combination of the residuum in the vacuum with a portion of the carbon, forming carbonic acid. In the latter part of the flame a dissociation took place; there carbonic acid was decomposed into carbonic oxide and free oxide. The oxygen came around and through some attraction of the glass, a static effect, the particles of carbon were drawn to the glass. That was his theory. If that were true incandescent lighting would be a failure. The first problem, then that Mr. Edison gave me when I went with him was to determine what that carbon was, on the inside of the globe, to analyze it and find out. Well it was only perhaps about a ten thousandth of an inch in thickness and the accumulation from a good many hundred lamps was required before we could even get a sufficient quantity to test. But I determined that in there was hydrogen, nitrogen,

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and some oxygen. That proved conclusively that the carbon had been bodily carried over; that it was a hydro carbon that was thrown off on the inner surface of the globe. That started him again about the perfection of the carbon which was the object he aimed at after that time more than the perfection of the vacuum, so as to get a carbon of very high melting point, in which he succeeded very well. Now there was another point which you asked about in connection with that—the carrying of the carbon, was it not—the migration of the ions. If you examine a shadow's direction, as the spectral shadows of the carbon on the glass after they burn for many hundred hours you will find that there is more of the carbon that is collected on both sides of that spectral shadow. The shadow is really the reverse of a shadow. It is a negative shadow. Now, if it was a migration direct, it would seem to me a current in passing around and carrying the particles with it, would throw them on the line of the plane passing the two poles instead of throwing them to the right and left. That is a phenomenon which is not explained by that theory. On the other hand, if the potential is too high and does not carry them around the curve with the carbon, it would tend to shoot them off in a general spray and the combination of those sprays, something like spray pictures where you put on an object at this distance would tend to leave the spectre of the negative on this side; so that it is practically to my mind a mechanical disintegration of the carbon.

MR. MAILLOUX:—Why should it have that spectral shadow? It occurs to me that there is something to say in favor of the electrolyte theory. I have given attention to that phenomenon myself, and I never could reach any satisfactory opinion until Dr. Moses just mentioned the fact that it might be an electrolyte. From my past reasoning on the subject, this idea strikes me very forcibly and I think the presence of the spectral shadow would be explained by the fact that there would be analogously an electrolysis. Given, then, the fact that we have an evolution of the ions of some kind or other at each pole, then if they are free to move in all directions, it is very plain to see that they must go more or less in the way of each other, because it would be probably Crooke's phenomenon, or something analogous to that, by reason of which they have some momentum given to them which would project them into surrounding space; probably the ions are given off principally at the ends where the carbons are attached to their conductors. They would be projected in all

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directions from that, and the above particles which were projected could not reach the back of the carbon filament on the other side, and consequently they would throw a shadow. They might be diverted and sent off on each side of it. The very heat would, perhaps, serve to divert them and send them in another direction.

MR. RAPIEFF:—A Frenchman, whose name I forget, once made certain experiments. He made a porcelain globe and put in a piece of carbon; he put the porcelain globe into another globe, all properly made, and exposed them to a white heat, about 2,000 to 2,200 Centigrade, for twenty-four hours. The result was that the first porcelain globe was penetrated by carbon, a heavy deposit of carbon formed on the top of it. After it was broken, the carbon was found to have passed through the pores and deposited on the second globe and outside surface of the first globe. It is conclusively proved that carbon has the power before the melting point to give forth vapors. If you run your lamps below the degree of incandescence, producing yellow or mellow light, then you have carbon not so high. But when you run your lamps or filaments recklessly, you bring it to a very bright incandescence, certainly it is above 2,000 Centigrade, then it might produce this effect.

DR. MOSES:—That proves very clearly that carbon will distill at different temperatures a different product. If you commence with the petroleum, you will get off products at 160, 180, or 200, and I should not be surprised if for every degree between there and 5,000 you would get off another product. In the ordinary air the difference between a vacuum of 50,000 and 1,000,000, would make on a 76 candle lamp, from 6 to 8 candles less of illumination; so that if you take a gas that is itself an excellent conductor, and that, as Mr. Grove himself says, comports itself very much like a metal, on account of its conductivity, why the loss is still greater.

MR. RAPIEFF:—It is not only from the cooling effect of the hydrogen but also the conversion of the heat.

Mr. MAILLOUX:—I would like to ask here if the form of the cross section of the filament of an incandescent lamp has not a great deal to do with the illuminating power or the economy of the lamp. In other words, is not the ratio of candle power obtained to the energy consumed, influenced by the cross section of the filament.

DR. MOSES:—Certainly.

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MR. MAILLOUX:—Is it not a fact that a lamp filament having a circular cross section would give a better illuminating power than a flat one for a given amount of electrical energy? Now, there is an experiment that was made by Prof. Forbes and which I think is fundamental in this relation. He took a large conductor—one of the largest sizes of wire—and passed a current through it, gradually increasing the volume until the wire reached its limit of carrying capacity and became red hot. He now took the same conductor flattened, that is to say, a conductor of the same area of section but in the form of a very thin ribbon, and he found he was not able to redden it by any means of crowding the current at his disposition. This shows conclusively to my mind that what is good theory, namely, that a cylindrical filament has the most mass with the least radiating surface, must be good practice also, and that a filament which is stamped out of a sheet of paper or fibre cannot be as efficient as a filament which is made of circular section, such as thread, or out of round fibre, or else with a carbon covered wire, or anything like that. It is a subject I have thought on a great deal and I have studiously looked over the current literature to find somebody who had expressed an opinion about it, but I have found nothing and I thought I would bring it up this evening, so as to have it included with the disinterested discussion that has been brought out on the incandescent lamp.

THE PRESIDENT:—The commercial lamps with cylindrical carbons seem in many instances to have given very high efficiency in the tests which have been reported, such as, for example the Woodhouse and Rawson lamp and the Stanley lamp. It may of course be nothing but coincidence, and I do not know that any exact experiments have ever been reported in relation to the form of a cross-section of filament, but I have observed that lamps with cylindrical filaments often show a very high efficiency. It would be very interesting, if somebody would take up that matter; it seems to be an important one. It is also possible that the lateral discharge which Mr. Rapieff has spoken of, between the terminals of the carbon within the lamp may be facilitated by the sharp corners of the rectangular filament. These would discharge in the form of a continuous electrical brush, if I may so term it. We all know that static electricity discharges itself with great facility, from a point or an edge, and that fact may play a part in the phenomenon.

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DR. MOSES:—If you consider the vibration of a cylindrical rod, you would find you get much more uniform vibrations from that than from one of a rectangular section. The whole theory is that the carbon would vibrate more readily and uniformly, because it is from a cylindrical surface. That is theory; but in practice you will find one advantage with regard to the sharp angles of incandescent lights. The steel engraving is much more agreeable to the eye than a mezzotint, on account of the scintillations—the white and black. Don't you find that to be so?

MR. RAPIEFF:—It is so, but they are from different causes. I want to tell you the advantage which Mr. Mailloux mentioned in the cylindrical compared with the flat. But the flat has one advantage, especially if bent as Mr. Edison has it. Under the heat, of course, the upper and lower particles are strained differently, and especially if you take the same section or area of the flat filament you would have in the round filament, the upper particles would be strained comparatively little.

DR. MOSES:—That is not the case, because the carbon having been put into the shape of a horse-shoe retains that shape.

MR. RAPIEFF:—Still, the elasticity is there.

DR. MOSES:—But it shows that the internal and external strain exactly balance one another. Now as to the point I wanted to make, of the advantage of a rectangular section, I think the pleasure that we receive from looking at a steel engraving is the alternation of the white and black line. The particles of white are so small that there is no sudden break. Now, the incandescence of the angle of those sectional rectangles, is of course more than that of the side of the rectangle, and we get therefore in that rectangular shape a much more pleasant light to the eye. You may all have observed in those carbons made from carbonized thread a much more unpleasant light, although it is the same amount of light.

MR. RAPIEFF:—You can attribute that to a different cause. Round filaments have smaller surfaces than other ones, and each unit of the row is brought to a higher condensation.

DR. MOSES:—If you look at that light intently for five or six seconds and then close your eye, you will see exactly what I mean.

MR. MAILLOUX:—But in practice we are not called upon to look at the light. We want the light to look at us.

DR. MOSES:—But we have got to look at the light in order to

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find out whether these effects are so; to make full experiments we have to look at the light, or look at the effects of the light.

MR. MAILLOUX:—If we look at it from its economical point of view, namely, quantum of light from a given amount of energy, and if it is shown that a cylindrical section gives a greater amount of light I do not think it matters what the scientific nature of the light may be, because we only use it to view objects by, and it is very much like an arc light in some respects. It is not a thing to look at, and whether it gives its light all from a little spot or from a larger surface does not matter especially, as "craquele" glass globes are generally used over them. We only want to get as much light out of it as possible and with as little expenditure of energy.

DR. MOSES:—If you take about a dozen strands of manila and carbonize them, so that their conductivity shall be the same as that lamp, and divide the current up, you will find that those small cross-sections have very much more incandescence than those larger sections, proving that, offering more resistance in proportion to the rest of the circuit, there is less current passing because it is on the same circuit, and yet you have more light.

MR. MAILLOUX:—I believe that sustains the theory you advanced elsewhere sometime ago in regard to the improvement which you must expect in the economy of incandescent lamps from the smaller section of filament. I believe Dr. Moses was the first one to bring out that very important point; and although I was not present at the time, yet when I read the report it gave me a great deal of respect for Dr. Moses's opinions, and I felt very much more anxious to make his acquaintance, because I thought he was doing some solid thinking in the right direction; that after all that had been said in regard to the improvement of the incandescent lamp, there has been very little improvement in practice But looking at the sectional form of the conductor and reading what he had said, it occurred to me that Dr. Moses had there advanced one of the most important points in relation to the improvement of the incandescent lamp, and that in that direction the future growth should be looked for.

THE PRESIDENT:—As the hour is late, I shall with regret be compelled to cut off this discussion which has been one of the most interesting I have ever listened to. I am sure we are all greatly indebted, not only to Dr. Moses, but to many other gentlemen present who have contributed valuable suggestions and information.

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MR. MAILLOUX:—I would like to put the fact on record at this our first meeting, that the new departure of The American Institute of Electrical Engineers, appears to be by far the most satisfactory we have had yet, not only in the number present but in the interest manifested in the discussion, and for my part I have learned more about one department of electricity—incandescent lighting—than I had learned elsewhere during the past year; and I hope this beginning is only a sign of a continuance in the same direction.

THE PRESIDENT:—For my own part I have been very much impressed with the extremely practical character of the discussion. I have had the pleasure of attending a great many meetings of scientific societies in this country, and societies in our own line of work in Europe, and I certainly think that there is more to be learned from such a discussion as we have had here to-night, than from any that I have been fortunate enough to attend on the other side. The English electricans are very fond of discussing things in what I may call a theoretical or doctrinal way, and many who participate appear to be very careful to give as little practical information as possible as to what they are doing in the laboratory or workshop.

MR. MAILLOUX:—I was about to say that in a previous meeting I broached the fact that in this country we were rather too practical; that we devoted so much time to practice that we had no time to give to theory at all, and I also expressed the fear of our being more a class of artisans than of scientists—to use words in their true application, that we were apt to be too much actuated by motives of self-interest. There is undoubtedly in this country a feeling which impels people to guard very jealously what they call their own trade secrets and I expressed the fear, that we might have to work hard to entirely eliminate that feeling and bring about in its stead a feeling of good fellowship which would induce people to come together, from every electrical sect, company, or art whatsoever, all knowing that they were meeting friends rather than rivals, and that they could give us their share of experience, their share of technical or practical knowledge, with the feeling that they were adding to the general sum of human knowledge and at the same time without fearing that their own particular trade, or their own particular "ism," would suffer from it; and I am very glad that this evening we have had a discussion which has drawn words from all who are interested in electricity, without

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reference to what I might call creed or faction,—from people interested in the same branch of electrical industry, I might say,—and yet who were to a certain extent separated from each other, not to say rivals in their business callings, and it shows that we have begun a good work in this our first meeting of this character, namely, bringing electrical men together and making them feel that they can do much to advance the progress of any art electrical in this country by putting their little mite of human knowledge into the big pile instead of keeping it in their own small heap. [Applause.]

Mr. Sidney F. Shelbourne was then granted the privilege of the floor for the purpose of adding to his paper read at the general meeting. His remarks appear as a supplement to vol. iii of the Institute transactions. The meeting then adjourned.

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Special Meeting.

December 7th, 1886.

The special meeting for the consideration of the subject of Electric Street Cars was held at 130 Broadway, New York, at 8 P. M., December 7th, 1886. In the absence of the president, Captain Otho E. Michaelis, who was invited to take the chair, called the meeting to order. Mr. T. C. Martin read the following paper:

ELECTRIC STREET CARS.

The great question agitating street railway companies in this country at the present time is the use of some motive agency more economical and convenient than horses. It is no exaggeration to say that after about half a century of patient trial they have become profoundly dissatisfied with animal power and are ready to adopt any system that can establish its claim to their preference. Evidence of their feeling on the subject is seen in the fact that at the last convention of street railway men, the progress of electric motors was reported upon by a special committee whose optimistic statements were heard with pleasure. One of the most prominent members avowed that he regarded the promise of electricity as a motor with which to supersede horses, as very encouraging. Another said: "All honor to those who are giving an hour or a dollar to the development of this important agent." A third thought it the duty of the convention to extend an earnest and cordial greeting to every man who was "trying to replace bad with good." These sentiments should, I think, encourage us, who, with enthusiastic pride, have seen the rapid increase in efficiency of the electric motor, and who, no matter what may be our predilection for particular systems, assert and know that—as a bottom and basic principle from which to start—electricity is more than equal to all the demands that may be made upon it in the special service of propelling street cars.

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The struggle for supremacy in this field of occupation may fairly be said to have narrowed itself down to three competitors —the horse, the cable, and the electric motor. Steam used directly is, it seems to me, viewed with more and more disfavor as the years go by, and has within city limits come to be considered very much in the light of a nuisance. The lowest cost of operation per steam motor per day, in usual service, that I have seen quoted authoritatively, is $8.50 to $9.00. But even if steam were cheap, there are grave objections on the score of noise, smell and dirt. The mere fact that steam locomotives have been in successful use fifty years, but are still denied employment on the streets, tells its own story as to public opinion. To some of us the banishment of steam from the tracks of elevated roads seems a matter of but a few years. As for gas, soda and compressed air motors, I am not aware that they offer any points of superiority over steam for the specific purpose under discussion.

Coming to horses, we find that in spite of their universal use and their faithful performance of duty, they inspire a discontent anything but complimentary, yet hardly to be wondered at. The statistics of horse-cars are important and interesting, and deserve our attention as covering the sphere within which the electric motor will operate. There are, according to the latest returns available for this year, about 625 street railways of all kinds in the United States and Canada. Taking of these 408 horse roads giving full and trustworthy figures, I find that they run 17,331 cars and employ 85,888 horses. If at the same ratio we took all the horse roads, upward of 500, we would arrive at a result of not far short of 25,000 cars and 120,000 horses, a total that probably comes near the actuality. Taking the other figures, which I have tested by three sources of information, it appears that all the horse-car lines are maintaining a proportion of at least five horses to each car. But that is inclusive, and making a reasonable allowance for the use of different cars for winter and summer, and for idle cars, as well as for "doubling-up" in heavy snows, a result is shown of at least eight to ten horses per car. This is the proportion usually cited, and it is brought out on a special examination of statistics for this city. Thus, the Broadway and Seventh avenue road has 121 cars and 1,350 horses, or not far short of 12 horses per car. The Central Park, North and East River road, with a total of 161 cars, has 1,223 horses, a broad average of 8 horses per car. The Eighth avenue road, with 112

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cars, has 1,155 horses, or 10 per car. The Forty-second street and Grand street line has 50 cars and 485 horses, or 9 per car. The Sixth avenue line has 127 cars and 1,296 horses, or 10 per car. The New York and Harlem with 164 cars has 1,321 horses, or 9 per car. The Third avenue road, returning a total of 360 cars, has to keep up a force of nearly 2,200 horses. The large number of horses required is also to be learned from the fact, stated by Mr. Augustine W. Wright, that those on the North Chicago line, which is a favorable sample, work daily only two hours and seventeen minutes. Or to put it in another way, the 6,158 street car horses of Boston travel each about 10 miles a day only, or two hours' service.

The costliness of horses may be arrived at in yet other ways by the use of comparative figures. Mr. T. C. Robbins of Baltimore, a street car expert, gives the average cost of a horse-car per day at $6.50. I have had the same figures given me for Brooklyn and Philadelphia; while Mr. C. B. Holmes, of the Chicago Cable Railway, who has had great experience with horse service, says that the expense per car-mile by the cable system is 10 to 11 cents, as compared with 20 to 25 cents per mile when employing horses. On a daily run per car of 50 miles, that would be at least $12 per day with horse traction, and half as much for cable. Moreover, there are the great extent of valuable land required for huge stables and the heavy depreciation of stock. Few occupations are more exhausting to horses than street car traction, and the average railroad life of a horse is but from three to five years. In other words, out of 100,000 horses, at least 20,000 every year die, or become useless for their work, and drag out the remainder of their existence in other occupations. "How are you getting along with those old horses I sold you," said the street railway president to Mr. Sexton, the undertaker. "Pretty well," was the reply. "I tried 'em first in the mourning coaches, but they were too slow for the ladies. Then I put 'em in the hearses, and I haven't heard any complaints from that quarter."

The cable has already made its way into use on a large number of street railways doing a heavy business, and is, it must frankly be admitted, a vast improvement on old methods. It has enabled those roads to handle a traffic that was utterly beyond their capacity before. It has accelerated speed, has lessened accidents, has given the streets a cleaner look, has, it would seem, cut down expense, and has certainly raised the value of property wherever

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put in. But I doubt seriously whether in view of the enormous first cost of the cable system and the excessive waste of power, it will make very rapid strides, especially when subjected to the rivalry of electric motors. At the recent street car convention, the new cable roads at Kansas City were presented for favorable notice, and as they were evidently considered good specimens, let us accept the figures. The Metropolitan road will cost $50,000 per mile of single track, and I observe that it is claimed with regard to the Philadelphia system that the track there could now be duplicated at about the same cost. The Kansas City cable company gives some interesting results of a test of its engines and machinery, from which I gather that with a total of 159.7 h. p., no less than 119.06 h. p. was required for the cable machinery, leaving only 40.64 h. p. for cars and passengers. In other words, just 25 per cent. was available for actual traffic. This waste will strike electricans familiar with the high efficiency of dynamos and their transmission of power as extraordinary. But it is confirmed by a statement from Mr. C. B. Holmes of Chicago, who says that his cable railway required for ordinary operation, engines of 477 h. p.; that it took 389 h. p. to move the cable and machinery, and that 88 h. p., or only 18½ per cent. was used for the propulsion of the cars at nine miles an hour. Mr. W. W. Hanscom, in a careful review of the conditions applying to the cable lines of San Francisco, gives a total daily average percentage on the seven roads of 68 per cent. of power for moving the cable, and 32 per cent for the cars and passengers. Two miles of new double track in San Francisco, fully equipped, have just cost $400,000.

I do not know that these figures call for comment, as those presented later on in regard to electricity will serve for purposes of comparison. But they may be supplemented by one or two observations. It is evident that there is an objectionable rigidity in the cable system and that it has narrow limits of applicability. A cable road, of whatever kind, needs a very large patronage. Mr. P. A. B. Widener, well known in connection with Philadelphia street railways, said last year: "To maintain a cable road you must have a certain amount of business in order to be self-supporting. It costs as much to run the cable for half a dozen cars as for half a hundred. Small roads, or feeders to the main line, are run more cheaply by horses." It will be remembered that great trouble was experienced in Philadelphia in rendering the cable system there operative last year. The assertion is made

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by those who should know that 12 miles, costing between $40,000 and $50,000 a mile, required $250,000 in repairs and renovation inside the twelve months; but, as the *Ledger* put it philosophically at the time of the breakdowns: "It is claimed that the delays and other annoyances that have been experienced by the company have been slight in comparison with those met with in Chicago when the cable road there was in its infancy." We New Yorkers and Brooklynites are more familiar with the mishaps on the East River Bridge, and from the arguments made here and elsewhere against cable roads we have learned that the cables wear out quickly, besides being ceaselessly noisy and requiring a conduit that must have such a depth as to become an unhealthy drain or sewer.

We reach now, in the due course of our survey, the use of electricity as compared with horses or cables. You will, I believe, bear me out when I say that the confidence of electricians in the ability of electrical means to propel street cars is as strong as it could possibly be, and is, moreover, based on no small amount of work and experience. I might affirm that the general introduction of electric motors is now largely a question of coal bills. I might affirm that it has more and more resolved itself into a question of mechanics; and in both statements I should have your concurrence. I may broadly state that in Europe, where a large number of electric roads exist already, they are paying well and multiplying; and that such roads in this country had, some months ago, carried altogether over a million passengers, or a daily traffic of 3,000 passengers for a full running year, without any recorded injury to a single patron, while several new roads have of late gone into successful operation. But at the risk of covering much ground with which you are familiar I shall venture to give an outline of some of the methods by which electricity is applied to street-car service, as well as some of the data establishing its claim to superiority. I do not know of any point on which a fair comparison need be shirked; I do not know of any difficulty that can balk the infinite variety of our electric art, and as this society has never hitherto had the subject before it, I am encouraged to go a little into detail.

We have, in using electricity for street cars, the option of so many methods that the very flexibility of the application becomes a recommendation. We shall, perhaps, best spend our time in considering three or four of the leading methods, with incidental

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reference to the peculiarities of individual cases in each. I propose to take the third-rail system, the overhead system, the conduit system and the storage system, and, without any intention of invidious discrimination, to pick out, for the exemplification of each, some of the roads and cars that have been running or can be seen and tested.

Let us begin with the third-rail system. The Daft road at Baltimore, now in its second year, has been so often described that full details here are not necessary, but it furnishes some interesting figures. The cost of electric power there against horse-power at $6.50 per car has been $4.00 per car per day, with an increase for the year of 83,986 passengers. Mr. T. C. Robbins reported as follows to the street car convention: "It was started on a purely commercial basis, as a purely commercial transaction, and has continued, and is now being extended, simply because it has proved its right to stay by the performance, which leaves little to be desired." The largest item in the expenses at Baltimore is coal at $3.50 a ton. Another third-rail road, the Highland at Detroit, on which there are none of the grades and curves that rendered the Baltimore road expensive as to fuel, is in very successful operation. Like the Baltimore road, it has a wheel for making contact, but, unlike it, has the third rail neatly sunken between planks. It runs out of the city for three miles. The car in use is the same as those on Broadway, this city. Mr. Frank Fisher, whose motor is used, informs me that on a recent Sunday on a thirteen hour schedule, the road carried 5,500 passengers. The coal consumption was a little over 400 lbs. The coal—screenings—costs $1.25 a ton. The success has been so great as to lead to a development of matured plans for the increase of the service there and on a new local road to be begun in the spring.

You will agree with me, I think, that third-rail systems must be limited to a low electromotive force, and to suburban or rural districts. Even there they have a large opportunity.

Coming to the overhead conductor systems, the Van Depoele roads form an important group. These roads are now in operation at Detroit, Port Huron, Mich.; Windsor, Can.; Appleton, Wis.; Montgomery, Ala.; and Scranton, Pa. Mr. Van Depoele suspends his feeding conductor by side poles, or, as at Appleton, has double wires, corresponding to the track, but immediately above it at a height of 18 or 20 feet. The little Windsor road, two miles long, with two cars, started in June, 1885, has paid for

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itself. I may mention that when I went on it last August, one evening, I visited the generating station. It was deserted and in black darkness. I made the trip and then went back to the station. The darkness was blacker, and there still was no sign of attendance, but the 30 or 40 passengers each turn were none the wiser and none the worse. I don't approve such practice, however. The Appleton road, with five cars, is the first in this country run by water power, depending, and with great success, upon a pair of turbines that will develop 100 h. p., and are now driving a 60 h. p. dynamo. The Montgomery road is notable as being a complete city system, including ten miles of track. The Scranton road that started last week has two features of special interest. One is that in a city of about 50,000 or 60,000 inhabitants the use of the overhead conductor is allowed. Another is that the line is operated from the electric light station. The road is 2½ miles long, with 12 grades, mostly over 6 per cent. There are already in use two heavy Pullman cars, running at a speed of from 4 to 15 miles an hour. The current is conveyed by a conductor $\frac{3}{10}$ of an inch in diameter, the rails forming the return. A traveler with rollers and a flexible cable passes the current to the motor, which, it is worthy of notice, stands upon the front platform in sight of the driver. The electric light station is well satisfied with only $9 a day for running the 60 h. p. generator, and it is evident, therefore, that an increase of rolling stock will involve very little increase in cost of power. Here is a hint by which electric light men nearly everywhere might profit.

In the overhead conductor category should be included Mr. Daft's new roads at Los Angeles, Cal., one 3½ miles long and the other 2½ miles. A peculiarity is the placing of the motor in the centre of the car, occupying the room of but two passengers, and leaving both platforms clear.

The overhead bare conductor systems are also restricted to currents of low electromotive force. But they, as well as the third-rail systems, do work it is impossible to perform remuneratively by cable, and which would often be beyond the range of horse or mule power on either philanthropic or business principles. Provided permission is obtainable for running the wires, the overhead conductor system seems cheapest, if not best, for cities up to at least 50,000 population. I believe a double overhead conductor system well built should cost from $1,500 to $2,000

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per mile. The single conductor is, of course, much cheaper.

There are in the United States about 40 cities with population above 50,000. In almost every one of these it would be necessary to resort to the electric conduit system, third on our list, unless the storage system be tried, or a combination of the two. At the present time, the outlook for electric railways with conduited mains is very favorable.

The first exemplification of a conduit system in this country was given by the Bentley-Knight Electric Railway Company in 1885, at Cleveland. A working section of their line can now be seen at the Rhode Island Locomotive Works, and as it illustrates in a striking manner the principles involved, I will touch on a few of the leading points, now described for the first time. The conduit is made to resist the heaviest wear and strain of street traffic. The surface opening, or slot, is only $\frac{5}{8}$ of an inch wide, and the total width of metal at the street surface is but 3 inches. The conduit is kept clean by a broom of peculiar shape suspended from the car. This broom is said to have swept out in a single trip the accumulation from 12 hours constant snowing. At convenient points catch-pans with sewer connections receive the sweepings and effect drainage. The two main conductors consist of channel iron connected by expansion joints and lined with a continuous strip of copper of sufficient size to carry the current with but small loss of energy. These conductors are fastened to the side walls of the conduit on insulators of vulcanized wood dipped in white lead. The insulators are strongly set in sockets in the cast-iron supporting yokes. Neither the traffic rails nor the conduit structure form any part of the electrical circuit. To provide for switching, a movable tongue is pivoted at the point of branching, so as to rest on the top of the conduit and to be readily set to close either of the branch slots and direct the contact plow into the other. A corresponding conductor tongue within the conduit is moved at the same time. The contact plow for making connection consists of a flat frame hung from the car by transverse guides, on which it is free to slide the whole width of the car and extending thence down through the slot of the conduit. It is provided with a swivel joint, so as to adjust itself to all inequalities of road or conduit. This frame carries two flat steel insulated conductor cores, to the lower ends of which are attached by a spring hinge small contact shoes of chilled cast iron that slide along in contact with the two main conductors. At

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the upper ends are flexible connections leading to the motor. This plow can be inserted or withdrawn through the slot at will, the spring hinge allowing the contact shoes to straighten out into line with the conductor cores when the plow is pulled upward and the shoes strike the insulating lining with which the slot irons are provided. By no accident, therefore, can anything be left behind in the conduit to obstruct succeeding cars. The plow guides are hung on transverse axes, and are held in a vertical position by a spring catch that gives way when the plow meets an irresistible obstruction, and hence the plow is automatically thrown completely out of the conduit without injury, being also immediately replaceable. The contact shoes will stand weeks of wear, and cost next to nothing. The frame of the plow has wearing guards of hardened steel wherever it can touch the edge of the conduit slot, and these are also readily renewed. Two plows are used on each contact for the sake of absolute reliability, and to prevent flashing at the contact. The connection between the wheels and motor consists of a system of gear wheels and connecting rods, the gears being deadened so as to be quite noiseless. The company makes a completely equipped steel frame truck, with motor, etc., upon which can be placed any car body. These have a wheel base of 6 feet, a standard gauge of 4 feet 8½ inches, and can be used on curves with a radius of 45 feet. A motor of the Gramme type is used under the car. For long distances the motors are in series, with current constant; for short distances, the motors are put in multiple arc, and a new form of resistance is used.

Such are the main features of the system. Of its eminent practicability there should be no doubt. The question again is one of expense, and I therefore give transcripts furnished me by Mr. R. W. Blackwell, of actual estimates submitted quite recently and now under consideration. The first is for the equipment of existing street railways in the city of New York, 3 miles, 1,440 feet, double track, minimum headway 1½ minutes, average speed 7 miles per hour, running 24 hours per day, very heavy traffic, maximum grade 3 in 100.

CONSTRUCTION AND EQUIPMENT.

Conduit and conductors, 34,560 feet, at $3, $103,680; motor trucks, 37 at $1,200, $44,400; 50 h. p. dynamos, 12 at $2,500, $30,000; steam power plant complete, $27,750; foundation, $5,000; engineering, $3,000—$213,830.

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ANNUAL EXPENSE.

Coal, 14 tons per day, at $3, $15,330; engineer and assistant, at $2.50 and $2 per day, $1,642.50; firemen, 3 at $1.50 per day, $1,642.50; machinists, 2 at $2 per day, $1,460; total running expenses, $20,075. To which should be added interest on construction cost ($213,830) at 6 per cent., $12,829.80; and also depreciation of plant at 3 per cent., $6,414.90; total expense and charges, $39,319.70.

The second is for a down-town cross-town road in the city of New York, greatest grade 1 in 12, double track: 12,660 feet conduit (extra heavy), at $4, $50,640; 20 motor trucks complete, at $1,200, $24,000; six 50 h. p. dynamos, at $2,500, $15,000; steam plant complete, $20,000; foundation, $2,000; engineering, $2,500—$114,140.

Of course, I do not present these figures as those upon which all authorities are agreed, but they have their value as being bids on actual work.

The conduit system of Mr. W. M. Schlesinger, in use for four months past by the Union Electric Company at Philadelphia, with a car running 9¼ miles an hour, has noticeable peculiarities. It consists practically of two conduits, the upper of heavy channel iron for connection, the lower of wood or cement for drainage. To insulate the conductors, an angle iron is riveted to the top flange of the channel iron in such a manner that one of its flanges, pointing downward parallel to the main side of the channel iron, forms one side of the slot. In the inverted trough thus formed, the copper bar conductors are fastened, the contact being on the under side. Against the conductors, pulling upward, rub or press springs, making a firm, close contact under control by means of a frame holding the springs. In Mr. Schlesinger's system, the motor is under the car between the axles, and geared to them by means of chains. The motors are intended to work in multiple arc.

There are other conduit systems, among which I might mention the Van Depoele used at Toronto, I believe, in 1884, at the exposition. But my object is not so much to describe all the systems as to bring up main features and relative costs. I will, therefore, pass on to point out that whereas in the cable system, with its costly conduits, the available power for the cars and passengers reached only about 25 per cent., in the electric conduit

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system, requiring for generators, conduit and conductors, etc., but half the outlay necessary on a cable system, the net return of power, as you are well aware, reaches at the minimum from 50 to 60 per cent. Mr. G. W. Mansfield, who has had considerable experience with the Daft company, puts it as being at least 56 per cent. I note, too, that with the use of the Holroyd Smith conduit system, the Blackpool road, England, has reported earnings of $1,735 in a week, with a total expense account of $225, running 2,760 miles, and carrying 44,306 passengers.

A distinguishing feature of the conduit system is that it is the only one with which high potentials can be employed on the streets. With it, also, the power stations can be placed near ample water supply or where rents are low, or can each be given a section of road to operate.

I approach the next and last system on our list, that of storage, with some degree of nervousness. In more than one quarter, the man who comes out with a kind word for the secondary battery is set down as either a knave or a fool. I cannot see why he should be regarded as either, although he may perhaps be more than ordinary sanguine and hopeful. I have myself ridden very comfortably in a street car propelled by storage batteries, so that I know the thing can be done, and I understand that storage is to be extensively used at an early date by the North Metropolitan Tramway Company in London. At Antwerp, in 1885, after six months' competition with four other cars using either steam or compressed air, the Julien electric storage car took the first prize, awarded by a jury of well-known experts. There were in all twenty-three points of comparison. The Julien car has since been tried in Hamburg, and another has been in operation on the Eighth avenue line in this city. Mr. Widener, of the Philadelphia cable line, has traveled on it and is to try it, being very favorably impressed. But, as he remarked publicly, "The question is as to the cost of maintenance of the cars and the furnishing of motive power." It will be admitted that there are advantages in having each car an independent unit, offsetting the disadvantage of carrying the dead weight of batteries; and that single cars on any road can be taken in hand for change, so that existing rolling stock can be progressively adapted to the new conditions. This involves a smaller initial outlay and gives opportunity to train the present force in its unfamiliar though simple duties. Now, regarding

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first cost—I have never seen any figures as to the expense of an equipment of a car here with storage batteries. It has been said that two sets for an ordinary street car would cost about $1,500. That seems high. The Julien company states that the cost of the horses for a car more than covers the initial outlay of the change, and I believe the firm estimate is also made by the company of a total daily running expense of not to exceed $5 per car in cities on heavy traffic. As to life of the batteries, those in the Hamburg and Julien car have now been in daily use since April, and they show by test a return of more than 80 per cent. of the power with which they are charged. The car is running on regular daily service. In respect to American storage batteries, it may be mentioned that the Electrical Accumulator Company, whose officers have a standing in electrical circles, guarantees two years' life for its new battery and an 80 per cent. return of power. The criticism has been made that ordinarily 20 per cent. of the stored energy is retained on each emission, but obviously that is no loss, forming simply 20 per cent. of the succeeding charge.

Putting it broadly, the storage system, in spite of its various conversions of energy, has a superiority of at least 25 per cent. over cables. Some of you will put it far higher, but as I have said, in the absence of the data of prolonged work, I prefer to put it low.

I think we shall see a number of efforts shortly made in the direction of using secondary batteries for regular work on street cars, and the results will merit our most careful study. There are, moreover, some ingenious propositions for combining the conduit and storage systems, so as to enjoy the benefits of both. Mr. J. M. Pendleton has described a plan of his of this nature, and Mr. Elias E. Ries, of Baltimore, has also carefully elaborated such a system, in which storage plays an important part.

Here, then, illustrated in a variety of ways and by numerous examples, we have a comparison of electricity with other power for propelling street cars, and an idea is given, very imperfectly, of the wide range of choice that electricity itself offers as to methods and means. Much of what has been said has its direct and favorable bearing on elevated railway traction, as well as on that for underground railways, but the time will not permit me to pursue the subject any further. Many points of discussion arise as to the connection of the car axles with the motor; the use of independent motor cars or of motors on the passenger cars;

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the types of motors and of conduits or conductors; the potential that is safe under certain conditions; the methods of regulating motor speed; the use of resistances; but all these and others I may leave to you, many of whom are doing practical and creditable work in this field, and who by thus "hitching your wagon to a star," have shown that street cars, if run by electricity, may yet be brought up to the most advanced notions of humanity, comfort, convenience and economy.

All that remains is to press onward and occupy the pre-empted territory that awaits us. As Emerson says: "Our duty is plainly not to throw ourselves across the track, not to block improvement, not to sit still till we are stone; but to watch the uprise of successive mornings and to conspire with the new works of new days." This sentiment may surely be appropriated by modern electricians, who every year put their skill to some severer test, and every year win fresh triumphs. In beginning this street railway work, we may count on a large and profitable travel for some time to come, through the mere novelty of the thing, but as the art improves it will more and more manifest its right to street railway propulsion on the strictest business principles, as well as on every other ground of merit.

DISCUSSION.

THE CHAIRMAN:—Gentlemen, I am sure that we have all listened with great pleasure and profit to Mr. Martin's exceedingly interesting, simple and lucid paper, and I now declare the subject open to discussion. In this connection I desire to say that under the rules of the Institute our guests here this evening, who are not members, are invited to take part; and I beg to assure them that we shall be very happy to listen to any remarks they may desire to make.

MR. JOHN MURRAY MITCHELL:—Although I came in nearly at the close of the reading of this paper, I have been extremely interested, and have listened with great attention to everything said by Mr. Martin, and have arisen only for the purpose of corroborating what he has said in regard to the Baltimore road, and also to direct your attention, and I think perhaps also his, to the fact that in the comparison shown in his report between horse power and electricity, that the ratio given of $6.50 to $4.00 is not so advantageous to electricity as it should be, because the average speed which is accomplished there with electricity is eight miles

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an hour and the speed formerly attained was only four miles an hour, which of course reduces the cost in comparison—so that the cost of electricity should be put at about $2.00 as against $6.50 instead of $4.00 as against $6.50. That I know has not been brought out by Mr. Martin's report directly, but I think it worthy of attention.

I should also like to state that as counsel for the Safety Electric Railway and Power Company, which operates under the Daft patents, I had the pleasure some two months ago of closing a contract in Pittsburgh for the equipment there of a railroad to be two and a half miles in length, where the grade is 14 per cent. going up one of those terrible Pittsburgh hills. We first thought of equipping it without any safety device and relying on the mere traction attained by electricity and the weight of the motor; but as there happened to be a curve with a fifty foot radius on the grade of some seven hundred feet to the mile at that point, and as this happened to be on an elevated structure, something like our elevated roads, and as the danger, if there should be a slip of any kind in going around that curve, would be very great and would result probably in great loss of life, we thought it better to adopt a system which Mr. Daft himself examined and approved of, using a species of cog rail, but doing away with the old form of cog. It answers the same purpose without having the disadvantage and expense of the old system. That road I think will be fully equipped and probably be running in the early part of next summer. We have there the underground conduit, which is being constructed by Mr. Wharton, of Philadelphia. He took the sub-contract. He is a man who has built a great many of the cable roads. We have a very strong form of conduit, it being formed of slot rails, seven inches in neight and they are supported by ties and also by chairs which are made very heavy and almost strong enough to firmly hold the slot rails without any other support. This road also has the overhead system, making a combination of the two which has not been previously tried in this country; and I hope that at the time that that road does run I may have the good fortune to see a great many of you, gentlemen there, and I ave the pleasure of taking you out on the first ride.

MR. WETZLER:—Mr. Martin has remarked in his paper that one of the principal points to be considered was the coal bill. It is interesting, therefore, to note that in the case of the Julien

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Electric Railway at Hamburg, a calculation has recently been made on the basis of sixteen hundred kilometers run, equivalent to about one thousand miles. Mr. Huber, the engineer there, calculates that for the thousand miles run, the energy required to propel the car one kilometer is three-fourths of a horse-power per hour, on the average. Now, that figures out in this way. Assuming that three pounds of coal per horse-power per hour is what a fair average engine will do, the energy of coal required to propel the car one mile would be three and a half pounds of coal per car mile. Now, take, for instance, the Third Avenue road in New York. On a basis of three and a half pounds of coal required to propel a car a mile, we should have, assuming there were three hundred cars—I think Mr. Martin puts it at three hundred and sixty—that would give one hundred and seventy-five pounds of coal per car per day. I am basing that on a run of fifty miles per car per day. That would give 52,500 pounds of coal a day, or twenty-six and a quarter tons. Calculating a ton at three dollars, we should have for the coal bill alone per day, only $78.75—and that is with accumulators. I think the company would be very willing to spend $78 for coal, if that will do it. That is what it figures out at.

THE CHAIRMAN:—We have a press of various gentlemen, not only well known but distinguished in connection with this branch of the subject that we are studying, and I am going to take the liberty of calling upon some of them. First, I will call upon a distinguished foreign gentleman who is with us, whose name has been specially mentioned as familiar to us all, Mr. Julien, assuring him that we shall all be delighted to hear him speak on the subject. One of our members present will be very glad indeed to translate what he has to say, in case he will favor us. (Applause.)

MR. MAILLOUX translates to Mr. Julien the remarks of the Chairman.

MR. JULIEN addressed the meeting in French.

MR. MAILLOUX translates:

MR. JULIEN expresses his thanks and his extreme gratitude for the honor conferred upon him, and wishes to say that as Mr. Martin has entirely covered the points in his paper, it is scarcely necessary for him to elaborate them further, and that he could only speak of personal matters if he were to attempt to discuss the subject; which he thought might perhaps not seem acceptable.

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Upon my assuring him that such would not be the case, he consented to go on and give us some details.

One point that I interrupted him for, because I do not wish to forget it, was the fact that he brought out so clearly—although I dare say not many of you understood it—that the circumstances, under which the tests were made in Antwerp, were such as to represent almost an inimical attitude to the question of electrical traction by any process whatever. He said that during the six months that the tests lasted, every detail of the system was subjected to the closest scrutiny; that the cells were sealed and that they were almost kept under lock and key; that he was scarcely allowed himself to look at them. The tests were made by judges, the most competent engineers and electricians, and they were made with every precaution that might be necessary to prevent any tampering with the regular order of procedure, and, as he facetiously remarked at that time, there was a feeling which was quite current in general engineering circles that there was not much reliance to be placed upon electrical traction, particularly by accumulators, and also by electricians—that even electricians themselves were in such an infantile state of evolution that it might be well enough to wait until they had grown a little more, and as to accumulators, that it would be well enough not to think of them for some time.

Mr. Julien continued in French.

Mr. Mailloux continued translating:—

Mr. Julien remarks referring to the statement made by Mr. Martin, and the assertion made by Mr. Wetzler, that the cost of energy necessary for electrical traction is three-fourth of a horse-power per kilometer, and that as the energy required for the lamps must also be counted in, which he thinks would certainly be 10 cents a day, the total expense of about three dollars would be necessary for the energy actually needed, and counting an expense of two additional dollars for all other costs of maintenance, wear and tear and interest, and various other expenditures, that we would arrive at the cost of five dollars, which has been mentioned by Mr. Martin. Mr. Julien said that the cost was thus found by the experiments made at Antwerp, and that this cost might be considered, so to speak, historical; that it might be conceded to be the cost on which we could safely calculate the probable expenditure of running the electrical car.

Mr. Julien mentions a very interesting case of his desire to

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submit his system of electrical traction to the electricians of Paris, and to a committee, and to exhibit it there and let it be tested in order that the figures and statements as to its value might be corroborated and that also the facts as they have been found at Antwerp might be known more generally. He states that there also he found a great deal of opposition; that the French electricians had been almost systematically preaching against and slandering the accumulator. (I might remark incidentally that perhaps they had had too much of Mr. Phillippart in times past. That may have had something to do with their disgust.) At any rate a jury comprising some of the most able electricians was selected. Mr. Julien's endeavor was to place himself under exactly identical conditions with the system of electrical traction which was exhibited by the firm of Siemens at the electrical exhibition of 1881, and to make a comparison with that on the score of cost, facility of running and various other conditions; and that although the jury comprised men of conservative inclination and disposition like Fontaine, Hospitalier and others, men very well known themselves in connection with the application of electric motors, and although M. Fontaine himself took charge of the accumulators and discharged them himself and did not let Mr. Julien have anything to do with the manipulation, he said that he had received a dispatch this very morning, stating that they had conceded every point that he had made with them, and that they had found the figures as to cost, which he had given them as being the figures representing the cost at Antwerp, had not even been reached; that the actual estimate of cost of running under the conditions at Paris was much more favorable than those arrived at in Antwerp. (Applause.)

I must not forget to mention the most important thing, namely, that he has received two diplomas of honor, one for the car and one for the method of accumulators.

In reply to a further question which I asked Mr. Julien at the end—but I had so much to remember that I forgot that—he said that the experiment had been going on since last July with two cars; there were two cars in continual operation, so that the test could be made very thoroughly and the expense arrived at very correctly.

Mr. Julien continued further in French, and Mr. Mailloux translated as follows:—

Well, gentlemen, I have managed to get along so far pretty

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well; but I doubt very much, as good a friend as I am of the English language—I speak it pretty well—it is my native language, and as much as I think of the good old Saxon, I doubt if it is adequate to express the very eloquent and beautiful peroration Mr. Julien has just given us; but I will make a feeble attempt. It is nothing more nor less than *spirituel*, extremely well conceived, brief and to the point. His idea is briefly that he does not wish to occupy your time any longer by talking himself. He does not think it is well for people to say too much of themselves. He thinks he has already taxed your patience, but he merely wishes to add that he would be happy to demonstrate here in America the facts and theory, and the system which he is interested in, to the satisfaction of all those here present, and that he will consider himself happy, if, in coming among electricians of an intelligence as developed, and of a genius for invention as skilled and as well known as that of America, he has succeeded in contributing one stone to the great edifice of Science, particularly that of the application to the subject of electrical traction. (Applause.)

THE CHAIRMAN stated that he saw present a gentleman well known to all in connection with the subject, whom he desired to call upon—Mr. Van Depoele. (Applause.)

MR. VAN DEPOELE:—Gentlemen, I think you know nearly as much about it as I do. Everything has been stated this evening, and I can simply corroborate what has been said. Still there is one little plant that I might give the exact cost of, because the cost is about the main thing in the whole business here. We ran a plant in Minneapolis, Minnesota. This is, I believe, the most extensive electric railroad ever run in this country or anywhere else so far as I know. We had there about a sixty horse-power motor, and the train consisted very often of over ninety tons weight. We have run it for almost nine months. (I might state also that they have tried a soda motor there, which I will speak of later.) But at all events, we have been running there at an expense of about three thousand pounds of coal a day—that is, starting up at six o'clock and running till half past eleven at night—and certainly any of the locomotives that used to do the work before, consumed as much as four tons of coal a day for the same work, which shows that although we have to transform our power twice, that we will still effect a great economy over the ordinary steam engine. Our system is not now run-

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ning there for the simple reason that some other parties persuaded the authorities there that they were going to bring them something wonderful to use in the shape of a soda motor (a soda fountain with a stick in it, or something of that kind). The soda motors came and we went off the track and let them on. But let me say, those soda motors can hardly pull themselves, and at present are lying there like a lot of old scrap iron in the shops of the railroad. Of course, the authorities there would not at the present time like to take back the electric motors for fear of stultifying themselves. But we ran very satisfactorily over that route, using only very crude apparatus. The whole thing was only a common freight car with four ordinary thirty-six inch wheels and an ordinary gearing from the motor to the countershaft and from the countershaft to the axle of the wheels of the common car. During that time we wore out only one belt and operated the road eighteen hours a day, hauling forty-seven of their regular railroad trains. So it was shown that electricity can be used for heavy work as well as for light work.

Another instance where we might give figures—of course all this figuring will come easier after we have big plants running—is this: We are now putting up a large plant at Montgomery, Alabama, where we will have twelve cars running; but so far as we have tried it— and the grades are six and a half and eight per cent. there; in fact there is not a foot of level ground in Montgomery—with two cars we have consumed an average of nineteen hundred pounds of coal a day, so that it costs about five and a half or six dollars a day with the two cars including the engineers' wages. That is a very small plant, and if small plants can do as well as that, the larger plant can do much better. (Applause.)

Mr. Julien made some further remarks in French, which were translated by Mr. Mailloux as follows:—

Mr. Julien wishes the privilege of speaking to say that he was ignorant of the fact that a fellow countryman of his, M. Van Depoele, was among us, because he would have felt it incumbent upon him to begin by paying tribute to the labors of an electrical engineer whose work he admires greatly. (Applause.)

Mr. Mailloux:—Mr. Chairman, I am interested in electric railway matters just as I am in other branches of electrical engineering, such as occasionally come under the province of an expert to be investigated. At the same time while I am watching its development I like to look at the subject from a practical

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point of view. There is a question which is now agitating the minds of practical engineers and which gives me the opportunity to ask Mr. Van Depoele a question. It is this: There is a great deal of doubt, a great deal of difference of opinion, as to the manner in which the energy shall be applied to the shaft of the driving wheels. I heard Mr Van Depoele say that he gears his motor to a counter-shaft, and that he conveys the motive power from that countershaft to the driving wheel by means of a link belt. Now that link belt is as I understand some to say, a bugbear of the electric railway, or one of them, and I would like to ask Mr. Van Depoele about the length of time that that link belt has been running; also about how much velocity it will endure with safety; that is to say, how many feet per minute will it run without making too much noise or without being strained unduly and also how long the link belt will last under those conditions?

MR. VAN DEPOELE:—I will be very glad to answer this question, gentlemen. We have some link belts running now which have been used for the last eight or nine months on street cars. We have tried several different modes of transmission—to gear directly to the axle of the car by a means which will alleviate the vibrations transmitted by the axles running directly over the road. There at once we have a flexible connection between the motor and the car in the shape of a link belt. The motor can stand on the body of the car itself, and consequently does not participate in the heavy vibration to which it would be subjected if it were carried directly by the axles of the wheels. Consequently with street cars that is about the best connection I can find at present. I would like to be understood that any ordinary belting in the market would not answer the purpose. We have a link belt which we had made for this special use. We have tried the cast iron belt and found that to make considerable noise, wearing out too fast, and incapable of running at a high speed. I have run at thirty miles an hour. I did not formerly believe myself that a link belt could do the work, but it seems when it is solid and correctly made you can run it at that speed without hurting it. The link belt used by us consists of two side pieces of steel pressed into shape and the steel side pieces are then fastened to a steel thimble at the upper end. Right through that steel thimble goes a pin, the pin catches the two lower ends of the next link and consequently there was no friction in the small parts but the friction is borne by the larger surface of the thimble. Right over

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the thimble is a steel roller. There is really no wear to the chain. We have had in Windsor, Canada, a chain running for about eight months, and in fact it is just as good to-day as when first put on. Of course for running fast we have to use another method.

MR. MAILLOUX:—Was the belt running at that rate.

MR. VAN DEPOELE:—The belt was running then I should judge at a rate about one-third less than the wheels.

MR. MAILLOUX:—Twenty miles an hour?

MR. VAN DEPOELE:—Fully twenty miles an hour; and at the end of the track I stopped to feel whether the belt was hot, and it was not even warm. Of course for heavy work and fast speed I think the link belt would not be suitable. Then you should have a direct mode of connecting. Certainly it is very difficult to get a good connection between the motor and the axles of the wheels, because to make a motor large enough to connect directly with the axles of the wheels without gearing, would require the motor to be too large. I think it would be out of the question to make it in that way for ordinary speeds and bring it within reasonable limits. But to gear back of course you would have to use some kind of gearing. Friction gear I do not take much stock in. It is not reliable; it wears out and there is always some trouble about it. Of course the cog gear is positive, but it makes too much noise. But if you put up gear that is solid and mathematically true and with good lubrication, I find there is not much noise when the gear is entirely covered up the same as we have in Scranton, which is noiseless. It is thoroughly boxed and works well and does not seem to wear, and fits tightly; although how long it will last of course we do not know. We have several sets running and they work well. If you gear back at one to eight, you will have a good deal of noise; one to four you will have scarcely any noise; one to eight there will be serious wear; one to ten of course worse. There is a medium between these proportions, and you will have to take your choice in making your plans; but the link belt I believe is the best thing for the street cars to-day, that is, a belt made specially for the purpose.

MR. MANSFIELD:—Mr. President and gentlemen, I think that one of my years should abide by the old saying that my father always used to hurl at my innocent head whenever I attempted to say anything, and that is, that "little boys should be seen and not heard;" and that is the way I feel here. There are so many

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older heads and so many more experienced heads in regard to the mechanical and electrical problems, that I feel incompetent to say anything which would be beneficial or instructive. But I will certainly support Mr. Van Depoele's remark that it is a most difficult and exceedingly troublesome thing to find any good me hod of connection between the motor and the driving wheels. He has spoken of a variety of methods of doing it, and there are other varieties yet of which he has not spoken. But referring to his remark that the link belt gives a flexible connection between the motor and the driving shaft—that is an excellent plan and w« uld be necessary where a flexible connection is needed. I would like, however, to bring up just this one point, that we have before us two distinct fields to labor in. One field is to equip the twenty thousand cars already in use in this country, running over some three or four thousand miles of track, and being drawn by some 125,000 horses, and with the system of construction which now prevails. The street railroad men of all men, I believe, are hunting not only for a means of propelling their cars, but also for better means and better methods of constructing their railroads. Now, with the existing systems of construction on a large majority of the street railroads of this country you would need your flexible connection and possibly leather belts; perhaps the link belts; possibly a good combination of gears can be devised to get this flexible connection. But the other field is that of new construction, and this is the field in which I think the electricians should specially labor. They should start now and not wait five or ten years, but convince the railroad profession and the street railroad men and the street railroad builders—the street car builders, rather—that their cars and that the street railroads must be built for electric motors. (Applause.) If then they are built for the electric motor, we can supply them with something which is perfection, which will entirely do away with a great many evils which necessarily exist with horses, and with every other me ns of drawing and propelling the cars, even to the cable (the cable has a limited field, it cannot operate branches successfully) and a variety of other ways which I will not speak of here. But with the electric means in the construction of new roads due to the marvellous flexibility of electrical application to street roads, there is no known or conceivable difficulty that electric motors and the application of electricity cannot successfully eradicate and overcome. (Applause.) So, then, with this simple mod st thought

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that the electric railroad men and the profession engaged in that work will impress upon the minds of all street railroad men, and all men interested in street railroads, that their roads in future must be constructed from the very outset for the application of electric motors, no matter by what system, but by the application of electricity,—then I think, and by that means only will we come to the general and successful application of the motors to every railroad throughout the country. (Applause.)

MR. MAILLOUX:—There are two points which I wish to dwell upon in what Mr. Mansfield said. I would begin with the last, although it may not be proper. He speaks of the correct method —evolutionary method of the electric railroad as being that in which the electrician anticipates all that now hinders him and warps him in the development of his problem by beginning from the very first, from the outset, to prepare the road for electricity, all its appurtenances and everything else. That is a conclusion that has already been arrived at in reference to electric lighting. You will find that in the new buildings, the latest large houses, factories, etc., we need no longer go to the laborious process of drawing wires through, or taking them up to the ceiling; but we anticipate them by preparing for any system of electric lighting and place wires inside of the ceiling instead of having to run them outside. (Applause.) There is an exact analogy to the remarks of Mr. Mansfield. I was very much pleased to hear Mr. Mansfield speak. I wished that he had permitted himself to go more fully over some of the fine morsels and choice bits with which he could treat us from his stock of experience. Mr. Mansfield has been intimately engaged in the study of electric railroading for at least four years past, and I do not think that there is anybody here who is better posted in regard to the intricate details and complications of the problem than he; (hear, hear;) and I have heard him speak particularly of that very question of transmitting power from the motor shaft to the driving shaft, and he made some very pertinent remarks in a previous meeting before another association on that subject, and I think it would be conducive to the general information of us all if he would briefly review what he said then, so that it may be published with the remainder. I have reference particularly to the methods he spoke of in connection with round belting, etc.

MR. MANSFIELD:—Mr. President and gentlemen, I must confess that I am considerably abashed at this method of treatment

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by Mr. Mailloux, and I did not come prepared to make any remarks at all, but simply to gather in all the points and all the morsels of information which I felt would be distributed and lavished with a free hand upon all who were present this evening, and I feel that any remarks or any repetition of what I have said before, in regard to the methods for connecting the motor to the driving wheels would be almost a waste of time; and there are many other most valuable points which we can discuss, and perhaps discuss with more profit and in more general ways. I spoke that evening — it was up at the American Institute, the meeting of the electrical section there—and simply gave an illustration, by means of diagrams, and very casual remarks of the different methods which had been used so far as I was familiar with them; and I can merely repeat if you so desire just those methods which I then presented; but I do not wish to discuss the efficacy of any single one of them. I said then and you can take that up if you please, that the most primal and the most perfect method obviously would be the application of the armature to the driving shaft direct. That does away with every particle of gearing. This method has been utilized by Mr. Daft in the Enos elevated railway system, which system has two driving wheels, with their shafts extending on each side. The armatures are keyed directly on the shafts. Of course the periphery of the driving wheel is small to allow a greater peripheral speed of armature. It was calculated for a certain speed, twelve to fifteen miles an hour. The main difficulty which I think there is in using this direct gearing now is simply a constructional one on an electric basis. The ordinary horse car wheel, if I remember rightly goes only some ten or a dozen revolutions a minute to accomplish the average speed upon the tramways. Now to construct a motor or an armature to go at that slow rate of revolution and develop any power you would have to go to just the extreme which Mr. Van Depoele mentioned and construct a pretty large motor. If you go into the electrical portion of it you will see that you must have a certain length of wire upon your armature to get what we call counter-electromotive force, and to do that at so low a rate of speed you would have to construct a rather large machine. Then there is of course the simple pinion upon the armature shaft, meshing into a large gear which is keyed upon the driving axle. That method is simple, but it has its objections, although if the mechanical details are

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properly carried out and carefully attended to and well proportioned even up to as high a ratio as eight to one or ten to one, I think that a very successful application can be made, and that is the device used on the Baltimore road. Worm gear can be used which is equally as simple as a pinion within a gear—well, it is equally as simple, but it is not as economical. The action of a worm in a gear is we have always been told a very brilliant method of losing power—that as high as thirty, forty, fifty, and even sixty per cent. of power is lost, due to friction of the worm within the gear; althought Mr. Reckenzaun, I believe, states that he has constructed a worm of a very high pitch and has constructed his gear to match, and that he gets a very slight loss, 15 or 20 per cent. if I remember rightly—I think he has figured it down to that—running in oil. Now then we go from that simple process to another, which brings in another factor and that is the introduction of a counter-shaft. We can drive from a pinion upon the armature shafts to a gear upon the counter-shaft, and again from a small pinion to a large gear upon the driving axle. Of course any little difficulties which were apparent in the previous case, would be increased in this case by the introduction of another gear. The noise, however, could be cut down by using leather belting; and there are a variety of leather belts—round, flat, angular and link belts, that have been proposed, which would take the rapid revolutions of the armature shaft and carry them to the counter-shaft with very little loss, and with not much noise, and then the slower running counter-shaft, with a pinion upon that, running the slow gear or slow driving axle can be arranged very easily, and will run with scarcely any noise, and with very, very little wear. The flexibility of this system then would be between the armature shaft and the counter-shaft, provided you wish to establish flexibility.

Now, of course there can be different modifications of this even, and I believe that I noticed in an electrical journal a description of one used by an inventor out west, in which he used a train of gears very similar to the gears that are on the lathe in the ordinary machine shops. That I believe is the perfection of complication and I do not know that I can go beyond the mere mention of it. So, with just this brief resumé of the various methods with which I am familiar that have been in practical operation, I should mention, perhaps, before closing, a method of direct running with no intermediate gearing, brought out

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recently by Mr. Stephen D. Field. In this a crank arm is used on the end of an armature shaft, the wrist pin of which is attached to the connecting rod. That certainly does away with all intermediate gearing, and if he can successfully cut down the revolutions of his armatures to apply it to a street car, with all the street car difficulties of going so exceedingly slow, as to just creep in the rear of a mule having two tons behind him and a very cross-grained disposition in front, if you can cut it down to that slow rate of speed, of course for tramways there could be nothing much better. But there is the "if" to conquer. For lighter suburban ways, where you have the right of way and where you wish to run at a rapid rate of speed, where you connect two places, one of business and one of residence, where the business man who has been laboring five, six, or seven hours a day down at his office wants to get home at the rate of two miles a minute to see his family and get something to eat, of course then the direct application is superb. (Applause.)

THE CHAIRMAN:—I believe I voice the general desire in calling upon Mr. Field.

MR. FIELD:—I thank you for the compliment. Replying to Mr. Mansfield's remarks, there are two ways to supply the speed of armature necessary. One is to confine yourself to the ordinary two pole machine, using a great deal of wire and iron, the other is to increase the number of poles of the machine. That I have accomplished and with only two brushes. Then again with regard to the conduits for city traffic I propose in introducing electrical traction on a line already established,—where the rails are laid on longitudinal sleepers—to take these sleepers out bodily and put in their place a hollow cast-iron girder, the top of which is capped with a steel rail with a flange carried underneath, so that you cannot get a horse's heel calk into the slot, but you can have your little carrier in there. Mr. Martin said that that was the way to carry very high potentials. I propose to carry more than one high potential, but at the same time have the minimum strain on the insulators. To accomplish this result I establish a power station at either end of the line, and carry a zinc potential in one conductor and a copper in the other. You will observe they run parallel. Now every car on the line receives exactly the same potential wherever it may be. By this means I can carry as high as a thousand volts, and with great ease. You have got to have this high potential with a great number of cars. There is

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no other way to do it that I can see. Then for very large motors I wish to call your attention to a little improvement. You know how they will spark unreasonably. I find that the spark is not governed by anything particularly. It seem to vary with the load and with the machine and with the man that works it. I thought I would let the spark govern itself. I have put a couple of brushes on the commutator at the neutral points and connected them with a motor, called the brush governor. As long as the regular brushes are at the proper point, there will be no current pass between those extra brushes, let the regular brushes get ever so little out of position and immediately the current commences to go through these auxiliary brushes. Force the commutator to a false position and upon its release it will automatically turn back to its true position; the result has been very satisfactory.

MR. PENDLETON:—Mr. President and Gentlemen: I felt to-night that I, as a visitor, might occupy the position that was spoken of by an eminent member of a whist club which I belonged to in referring to the gallery—that the gallery should always be silent; and I felt as a visitor to-night that that probably would be my position.

I am very much gratified at meeting here so many gentlemen I am acquainted with by name more than in person, and gratified also in having heard from Mr. Martin the excellent address which he has given to us. But in that address he took the occasion for saying that those who spoke well of the accumulator had been looked upon as knaves or fools. As the accumulator and its uses has formed the main subject of my investigations in electricity I felt that, although thoroughly consistent for the last five years in the matter, we had now arrived at a time when we could boldly face electricians and the public with the service, and the good service, that the accumulator was capable of. It is now some two years since its value in connection with electric traction came to my attention. I have appreciated and understood the remarks of our distinguished guest, M. Julien, to-night, one of the gentlemen whose name was thoroughly familiar to me as the associate of M. Camille A. Faure and whose intelligent work in the development and the application of the accumulator to traction was appreciated by us before his arrival in the country. The demonstration that has been made so far has only been thwarted by mechanical, and not electrical misfortune. I do not feel that on the subjects, to-night, which have been so thoroughly canvassed,

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I can give you any very interesting or pointed remarks. There seems to be nothing more to be said. But I will say that the subject of electrical propulsion upon railways is now attracting the general attention—I can speak of that—and our deliberations and the remarks made to-night will go far to instruct the railroad men of America in the fact which we have known long since, that the electric motor is the engine best adapted for their purpose.

MR. MAILLOUX:—I would like to suggest to Mr. Pendleton that he might tell us something about his system in connection with the accumulators which he has brought forward and which seems to possess some features of merit, namely, the combined conduit and accumulator system.

MR. PENDLETON:—The system which Mr. Mailloux has referred to is a combination of a conduit with an accumulator system for energizing the motor. On nearly all of the systems of electrical railway, there will be a necessity for distribution of passengers at the different termini, and it occurred to me some time ago to study up the matter in the way of refreshing the accumulator during service. Also, in the direct transmission of energy from the station to the car there is always the question of insulation and loss by resistance, which has formed a very difficult problem in many instances to solve, as we know by the experience on the different railways which have been established in Europe. But by combining the two systems, the convenience, the elasticity, will be found in taking the current directly from the dynamo, where it is the most economical, and over the parts of the line where resistance comes severely into play, the accumulator would afford for purposes of distribution at the termini, a means of propelling the car. To illustrate this more fully, I should say that a system where the charging station performed on the conducting track or conductors the double duty of actuating the motors and charging the accumulators at the same time, the accumulator itself could be made the means of governing the motor on that part of the line. When passing beyond the limit of the line where conductors existed, the chemical energy stored in the accumulator would operate the motor and at the same time be able to control it. For instance, supposing a line of twenty miles, or any other distance. A station would find difficulty, by the ordinary methods, in operating a motor located in a tram-car at that distance, ten miles on each side, from the station. But taking the ordinary variations of the line, the car would

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at times take seven or ten horse-power upon gradients and curves, while on the ordinary levels one or two horse-power would be sufficient to propel the car. Now, having on the tram-car the battery of accumulators, a simple system of connecting the accumulators into different combinations of two, three, and such series as would enable the electromotive force—the constant electromotive force—of the line to be varied, so that a certain proportion would be used at the motor and the balance would pass into chemical energy, and by varying in that way in going up a gradient the bulk of the electromotive force would operate the motor. In a down grade the bulk of the electromotive force would pass through the accumulators, and the ordinary accumulator, instead of operating the car under such circumstances thirty miles, might be made to operate the car for a day of fifteen hours, as when passing over the portion of the line having conductors, the accumulators would be constantly refreshed, and upon a portion combined for the purpose the accumulators would be available almost continually without stopping. That was briefly the system which Mr. Mailloux referred to, and the only matter in addition was the mechanical device which was proposed to be placed under any horse-car for the purpose of converting the cars now in existence into electrical cars, which would further the advance of the principle more rapidly than if it were required to build cars and introduce them, replacing the others. For that purpose it was suggested to my mind that by keying upon the axles a split worm wheel, a motor suspended from the bottom of the car would enable a connection by worm to operate advantageously where the dust could be prevented from entering the worms and where oil could be maintained to lubricate properly the worm and the worm wheel. Therefore keying upon the axle a split worm wheel bolted together; on the boss or hub of that wheel there was a box supporter which afforded the opportunity of placing two journals, one on each side of the worm. Both of the axles so furnished—the worms were made right and left—had reversed gears, one operating above, the other operating below, the axle. This relieved the thrust which would result from their being placed in any other way, and the friction and loss of power which the wearing on the collar would entail. The difficulty hitherto encountered in placing the motor where it would be subject to the pounding of the track seemed to be relieved by using a flexible axle. That is, on the armature shaft

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connecting with the shaft of the worm wheel about seven inches on each side was a spring or double spring, so that the flexibility of that shaft would allow for the difference of the load or from the wearing of the boxes. I had occasion to show the plan at the Electrical Society some time ago, and I doubt whether I have the power in language to give you a clear description without the drawing. But, so far, I have not had the opportunity of placing it upon a car, and although it has received the favorable comment of those who are expert in such matters, yet no man can promise from an idea, no matter how carefully studied, that which experiment only can prove.

CAPTAIN MICHAELIS leaving in order to take the Governor's Island boat, MR. MAILLOUX was called to the Chair.

MR. MAILLOUX:—We have with us this evening one of the gentlemen who is interested in financiering in connection with these matters—General Stiles, the treasurer of the Van Depoele Company, and I have no doubt he can give us some very interesting details and statistics—tell how much the roads are being run for and other matters of interest.

GENERAL STILES:—I presume that some one was laboring under the impression that I was an electrician, and I beg to assure you that I am not, and I know but little about electricity. Still, I think if I could get the worthy Chairman to interpret for me I might make a tolerably fair speech. I do not think I could say anything that would be of interest to you in the line that should be discussed here to-night. I simply know that with the Van Depoele Company we are operating some six roads every day. Our road is in operation at Scranton, and we would be very glad to see any of you there who desire to examine it. I have had great faith in electricity as a motive power and I have invested considerable money in it; and I have faith in electricians, especially Mr. Van Depoele. As I said before, I know absolutely nothing about electricity, and how little I know, perhaps, I could illustrate by a little anecdote. A young gentleman called on me a short time ago to engage as an electrician. He gave me his card as an electrical engineer. I asked him what he knew about electricity, and he said he knew all about it. Of course that satisfied me as it would anybody that was interested in the business; and I told him that I knew there were electricians and electrical engineers, but I had very grave doubts whether there

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was any such thing as electricity; and he attempted to convince me that there was, but failed, and left in disgust.

Gentlemen, I thank you for the honor conferred upon me in asking me to speak, but I really don't think there is anything that I could interest you with at all.

MR. MARTIN:—How many miles of track are you running?

GENERAL STILES:—I think we were figuring it up the other night—something like thirty miles.

MR. MARTIN:—Every day?

GENERAL STILES:—Every day. We have six roads; and what I consider the best part of it is, they are all paid for.

MR. MARTIN:—How many cars?

GENERAL STILES:—About twenty-eight cars. The road that we were running at Minneapolis is being run by steam cars. The cars were ordinary cars, the same as steam cars. We put it in as a temporary affair, to enable the company to run their cars until they could get some ordinance to allow them to run by steam. However, they have offered to purchase the apparatus of us, but they have had some misfortunes, especially in the soda-motor line. They were trying to operate four soda-motors made by the Baldwin Locomotive Works. The last time I was there Mr. Hill, the engineer—there were four boilers built by the gentleman—Mr. Hill called my attention to the coal on the floor, about two bushels. He said that was the last of thirty tons they had used to charge that one motor with, and they had not started it yet. So I concluded that there was something else required.

MR. MITCHELL:—I have heard about some "Great Eastern" motor at the Rhode Island Locomotive Works, in Providence. I understand there is a very large motor being built there, and I would be very glad personally to hear more about it.

THE CHAIRMAN:—I can state for the information of the gentleman that I was in Providence recently on a tour of examination of that particular system, and that at that time the motor was still on paper. They have a motor with a capacity of fifty to seventy-five horse-power for street traction; but they had not yet begun to work on the large electrical motor—that 600,000 watts motor which I understand you mean.

THE SECRETARY read the following communication from Mr. R. M. Hunter:

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No. 926 WALNUT STREET,
PHILADELPHIA, Dec. 6th, 1886.

RALPH W. POPE, Esq.,
Sec'y American Institute of Electrical Engineers.

DEAR SIR—

I expect to be present at the meeting Dec. 7th, but should I not find it possible, I would request you to state to the meeting that I find the prejudice against the practicability of electrical propulsion, which was so strong several years ago, fast disappearing, and that it is now the first thought as a possible motive power. My experience as expert for the National Cable Railway Company has satisfied me that cable traction is doomed, and that many of the cable railways now in existence will be converted into electric roads. This inclination was in existence even in 1883, when I had a project under consideration to convert the Chicago City Railway into an electric railway, and so far back as 1881 I endeavored to induce the Union Railway (now the Traction Co.) of Philadelphia to adopt electricity in place of their cable railway then building on Columbia Ave. The Cable Company is inclined now to believe in the change. At the present time the Hunter Electric Railway Co. is estimating for the construction of four roads, aggregating nearly twenty miles of track, with 110 motors, located in Pennsylvania and New Jersey. It is also negotiating for the equipment of a road in Massachusetts and a sub-company for that state, and another in Pennsylvania, aggregating at least thirty miles of track. The prospect for the introduction of electricity for street car propulsion is very flattering.

Very truly,

R. M. HUNTER.

After a few remarks in favor of continuing the special meetings, a motion to adjourn was carried.

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Special Meeting.

February 6th, 1887.

The Special Meeting for the consideration of "The Practical Requirements of Small Motors" was held at 130 Broadway, New York, at 7.30 P. M., February 6th, 1887. In the absence of the President, Mr. Sidney F. Shelbourne was invited to take the chair, who announced that Mr. Schuyler S. Wheeler would read a paper upon the subject for discussion, which would be accompanied by an exhibition of the working of the motor.

THE PRACTICAL REQUIREMENTS OF SMALL MOTORS.

BY. S. S. WHEELER.

It is a remarkable fact that not only have none of the small electric motors thus far put upon the market been constructed on the same principles as those of an efficient dynamo machine, but no attempts seem to have ever been made to copy large machines in the very features which are known to make them efficient and practically serviceable.

Any electrician, in looking at the motors heretofore offered to the public, can see at a glance why they cannot have a good efficiency, why their resistances are necessarily high, why they have to be run at too high a speed, or why their commutators will spark badly and quickly wear out, and why it is entirely out of the question to use them for giving power in thousands of cases. And yet, notwithstanding that these objections are almost entirely removed in large motors built exactly like large dynamos, no small motors have ever been manufactured before, which are any approximation to the larger machines in these important respects.

Probably the most important reason why so little attention or electrical ingenuity has been given to the subject of small motors is that the energies and inventive faculties of electricians have for the past three or four years been devoted to the problems of the transmission of large amounts of power, and especially the propulsion of street cars, etc., which present great difficulties, but difficulties that electric motors are especially suited to overcome.

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The natural result of this prospective demand for such sizes and kinds of electric motors as this work will require, has been the diversion of the best electrical talent in this direction, and the consequence has been the production of such machines, almost perfectly adapted to the requirements.

Meanwhile the subject of small motors has lain comparatively unnoticed. Each isolated want is of less importance to the user and of less value to the dealer than in the case of a large motor; in other words, as the small motor to be successful must be cheap, and the power to be supplied is small, there is little money in each individual case, and it is only when the number of individual users gets to be large that the matter of small motors becomes a promising field. It does not follow, however, from the lack of attention bestowed upon the subject, that there is no field for such work; on the contrary, there is an enormous number of individual instances where an electric motor would certainly be used if it be just good enough to come within the requirements.

In addition to the ordinary uses where we regard a motor as simply the best means of obtaining power for a certain purpose, for example, the running of a large number of small machines in a factory, where the motors and feeding wire take the place of shafting and belts, there are many places where the work would not be practicable without one, and where a motor, therefore, would be said to create the use. Such are all uses of very small amounts of power where an engine cannot be run, and which are beyond the capacity of a man at a treadle. There is a large class of uses for power where a steam-engine is not admissible, and where a good electric motor on a circuit is the only alternative, and in the absence of a motor good enough to be safe on an electric light circuit, or efficient enough to be run economically, all these industries have to be conducted in other ways, to avoid the question of small power distribution.

The response to the demand for electricity for lighting, has been the production of dynamos of ninety-five per cent. efficiency, a far better result than is obtained in steam-engines, and conversely these dynamos can be used as motors with the same efficiency. But the result of the needs of electric lighting, in response to which demand these dynamos have been created, is that they are machines of large power, and so in these we have motors of large power without further change, save as to means of regulation.

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Now why is it that we have not already had for some years motors of very small power, and reasonably near the same perfection of efficiency?

It is because a small motor while requiring the electrical construction and efficiency-giving features of a large dynamo, to be equally efficient cannot, for several reasons, be made an exact miniature of the large dynamo in mechanical construction.

If you want a 1,000 horse-power engine, you will get a Corliss engine, with elaborate valves, adjustments, etc. But if you want one of one-horse power, you will not get a miniature of the Corliss engine, requiring an engineer to take care of it. You will get a Baxter or an oscillating cylinder engine, with no external valve gear or adjustments, which will almost take care of itself. You must, to make a small motor successful for such practical purposes as it is to be used for, reduce the complication of its parts and its liability to get out of order.

Of course, this is realized by every one who has given the subject any consideration, but, nevertheless, the practical result has been that the only small motors thus far produced have been made apparently without any analysis of the difficulties to be met and any consideration of the means for overcoming them. Many of these motors have been so entirely unsatisfactory that they have been looked upon as little better than toys, and have reacted discouragingly upon the public.

Some of these motors, if placed on an incandescent circuit, for which they are intended, will burn themselves up. Others are of such very low efficiency compared with dynamos, that they require treble and quadruple the amount of current to give the necessary power. This is the principal reason why small motors, run from batteries, have not been more successful heretofore. The batteries have not been particularly bad, but the motors, instead of making good use of the current furnished, which is costly at best, have simply slaughtered the battery when pressed to do the work, by drawing four times the amount of current which would do the work, if efficiently used. I refer, of course, to the failure of the motor to give a counter E. M. F. when running, to which is due this inefficiency. The E. M. F. generated by a machine when driven as a dynamo, is the real test of its efficiency.

In order to get counter E. M. F. or magnetic effect, which is the same thing, and which is shown by running the motor as a dynamo and observing how much current it will *generate*, it is neces-

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sary to have a strong field, a large number of convolutions on the armature, and high circumferential speed, all of which are interchangeable as factors; while at the same time the resistance of the wire and the speed of the armature must be kept down. The first is necessary so as to permit strong current effects to be produced and large power to be exerted when the motor is running slowly, as well as to reduce the loss from the internal resistance of the machine; and the second, to avoid high working speed, which is always undesirable, for mechanical reasons. It will be observed that all of these requirements tend to the enlargement of the machine, especially of the armature.

These considerations lead to the conclusion that it is better to make the armature a little larger proportionately than it is made in large machines, in order that our very small motor may still have the proper amount of wire, etc., in the armature, and be a true dynamo, capable of giving a proper E. M. F., instead of being a mere electro-magnetic engine. By so doing we also make the armature much easier to manufacture.

There is now before the public a small motor, of which we have some specimens here to-night, in which the armature is enlarged radially, somewhat out of the usual proportion of armature to field, whereby the comparative strength of the field is perhaps reduced a little; but the armature capacity is increased in a much greater ratio, and consequently the E. M. F., or magnetic pull of the machine is large, and the internal resistance, as well as the shaft speed, is small. In addition to this departure from the usual proportion in order to meet the difficulties of small motors, there are a great many special features to increase the convenience as well as the efficiency of the machine.

As I believe this motor to be the first one on the market giving an efficiency corresponding to large dynamos, and at a price proportionate within 25 per cent. of the established prices for large machines, I think a description of it will be of interest. (I may say here that later on some tests will be shown, and an opportunity will be given of examining the motors and apparatus.)

The field magnets are of the simple horse-shoe shape, and the armature is a Gramme armature of comparatively large diameter and short length. The Gramme ring gives room for a large number of windings, with small mass of iron to be magnetized, and the large diameter, compared with the length, gives greater circumferential speed, with the same windings and mass. The

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cores of the field magnets are of best wrought iron, $1\frac{3}{8}$ inches in diameter and three inches long. The yoke and pole pieces are of equal section with the core, as is also the armature core, thus forming a magnetic circuit all around the horse-shoe and across the armature of uniform conductivity. The yoke and ends of the cores are cut clean by machinery, and firmly bolted together, and the iron fibre of the pole piece continues up into the core, both being in one piece and of equal section. The non-magnetic base plate extends around underneath, and forms a clamp for fastening the whole motor firmly to the edge of a table, a point of great convenience.

The armature is built up of about forty semi-circles of thin sheet iron, riveted together with two long rivets, into a solid ring, hinged on one rivet, so as to open on the opposite side to receive the winding. These thin laminæ of soft iron are separated by tissue paper, to prevent the generation of Foucault currents, precisely as it is done in the largest and most efficient dynamos. The complete armature winding, previously formed by automatic machinery, is slipped on to this split ring, which is then closed, the open ends of the half circles fitting into each other when brought together, forming a mortised joint, which is then secured by driving a final pin or rivet through them. When this hinged ring is closed, the core forms a hollow cylinder three inches in diameter, $\frac{5}{16}$ inch thick, and two inches long.

The armature winding consists of a flat wire or ribbon, wound on edge into a single helix, the full length of which equals the circumference of the armature. The commutator, which is of the disc type, consists of seventeen copper sectors riveted to a fibre washer. The latter is attached to a cylindrical wooden block which is turned true with the shaft of the motor, and to a tight fit for the inside of the ring, after the winding has been slipped on it. This block and shaft are then forced into the centre of the ring, until the outer extremities of the commutator sectors are brought within about $\frac{1}{8}$ inch of the winding on the ring. The claw-shaped outer tails of the sectors are then bent together, pinching tightly certain loops of the armature helix, which project out further than the main body, for this purpose.

These high convolutions or loops are then soldered to the commutator strips, making a solid and extremely simple and reliable connection.

The armature shaft is mounted in bearings, which are screwed

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to both sides of the pole pieces. The brushes are each held by a single screw, which also makes the connection with the leading wire, and, with the co-operation of the bearing plates, holds the brush at the proper inclination. The armature of this motor has room enough for a winding, such as described, composed of 204 convolutions and of sufficient conductivity to carry twenty amperes, half of the current passing around each side of the armature. Therefore, we may say that the magnetizing capacity of the armature winding is 2,000 ampere turns. Of course, the size of the wire in the armature may be changed to suit the circuit, so as to give a higher E. M. F. and less amperes, and still utilize the same amount of volt-amperes within this limit. Thus we may substitute for the 204 turns on the armature, 408 turns of wire of half the size, and still get the 2,000 ampere turns, when used on a ten-ampere circuit. The field is wound so as to carry the same current. The company is at present winding its motors with three styles of windings; the style designated A. is adapted to be used in 20-ampere circuits, such as the United States Co.'s arc light circuits; another style, designated type E, is wound for 10-ampere circuits, such as the Brush arc circuits; and the third style, designated L, is wound for 100-volt circuits or thereabouts, such as the Edison incandescent circuits.

In regard to the power and efficiency of these motors, I have found that when running at 1,500 revolutions per minute—a moderate speed for motors of this size—and, therefore, taken as the basis of tests, the 20-ampere motor, or type A, with 20 amperes passing through it, shows a difference of potential between its binding posts of 7 volts—5 volts due to counter E. M. F., and two volts due to resistance. This means 140 volt-amperes consumed in the motor, or a little more than one-sixth of an electrical horse-power. Under these conditions a Prony brake shows a pull of five ounces on a one foot lever; that is two foot-pounds per revolution, or about one-tenth actual horse-power at 1,500 revolutions per minute. The windings for other circuits give results to correspond. Therefore, when the motor is running with all the current it can carry, it uses about one-seventh horse-power of electrical energy, and gives about one-tenth horse-power of useful power, or 50 per cent. of the energy used, allowing for slight additional losses, which is about double the efficiency of any small motor which I have examined. And this performance is with a current heavier than can be carried by other small motors.

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When running with about three-fourths of this amount of current, or about 15 amperes, the efficiency is considerably greater, reaching about 60 per cent. This is the best working load for the motor, because the loss by resistance of the machine is less. But when we get down to about seven or eight amperes we find that the efficiency falls again, owing to the approach to the limit of weakness in the field. And when we reach four amperes, we find there is just field magnetism enough to turn the machine.

The loss of this initial current of four amperes in charging the field, is unavoidable, on account of the necessity of having enough mass of iron in the field to use the full two thousand ampere turns that the motor has, when fully charged, without bringing the iron too near the point of saturation, or, in other words, to make the motor large enough to use $\frac{1}{7}$ h. p. of current, without passing the point of saturation. Hence we see that if a motor is intended for use with a small current, it is better to make the field magnets of smaller diameter. This is another illustration of the difficulties to be met in making motors which will be good under varying loads.

In regard to its use as a generator, the motor with 20-ampere winding will give about 5 volts when running at about 1,500 revolutions per minute, and as its current capacity is 20 amperes, this means, allowing $\frac{1}{2}$ volt lost by resistance, 90 watts, or about $\frac{1}{9}$ h. p. of electrical energy in the external circuit. That is, enough to light a 16 candle-power lamp. By changing the size of wire and putting on sufficient convolutions to get a high E. M. F., we get a generated current of 1 ampere and 90 volts, sufficient for a 16-candle light, with a consumption of $\frac{1}{7}$ actual horse-power.

As the motor was originally designed for domestic use in running sewing machines with a battery, the current from which is necessarily very expensive, great stress was laid upon designing it so as to make the very best possible use of the current, for the sake of economical running, and also to make the motor as small and light as possible with the capacity required.

This latter consideration led to the immediate determination to use the very best wrought iron, and it is only by making these necessary elements of good construction, the first consideration in their manufacture, that a motor of this surprising efficiency has been produced.

In proof of the correct design and success of these motors, it may be interesting to hear that the semi-automatic machinery

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which was originally made for their manufacture has been kept in operation continuously for the last three months without interruption, and that already over six hundred of the motors are in use.

DISCUSSION.

THE CHAIRMAN:—I understand that Mr. Diehl is present with us this evening, who has had considerable experience and is acquainted with the details of the operation of motors and we should be very glad to hear from him.

MR. DIEHL:—I am not an electrician, but a sewing-machine man. I have, however, made some experiments with small electrical motors, and have made them of various styles. Some time since I placed one of them upon the market, but since then have made a number of improvements, and have come to the conclusion that the armature in small motors should have more sections than the one spoken of, which had only four. I have recently produced an improved motor intended more especially for sewing machines, the complete motor being housed within, or in direct line with the balance wheel of the machine and adjustably connected to the driving shaft. There is a great gain in this manner of connecting the motor, as no belt is required and therefore the friction is largely reduced. The armatures in my first motors were too small. I have found that they should be larger. I have built Gramme armatures, and think that for a small motor a diameter of three inches is a good size.

The motor which I intend for a sewing-machine exclusively, is entirely within the wheel of the machine. The armature is a Gramme ring, made in two sections. It is located by screws, so that it can be centralized. I have a field magnet in the inside of the armature. This gives me very good satisfaction. The wheel and motor together weigh about five pounds. The wheel is merely the housing for the motor. For fans and such purposes, I have built it in a different shape, but I also use the Gramme ring. I have come to the conclusion that it is a better shape than the H-armature.

THE CHAIRMAN:—Do I understand that the armature of the motor and the wheel revolve on the same axial line?

MR. DIEHL:—Yes; the armature is in the wheel; fastened to the shaft. It can be released from the shaft for winding bobbins, so that only the wheel with the armature revolves.

THE CHAIRMAN:—Is there any difficulty in placing more

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divisions on the commutator than before? I understand that the C. and C. motor has seventeen. Why not double the four in your case?

MR. DIEHL:—Well, I have from 12 to 34 sections in the wheel motor; in the earlier motor I had only four sections.

MR. MANSFIELD:—Mr. Chairman and gentlemen: I certainly would speak most heartily in commendation of the ingenious methods which the C. and C. Company have adopted and devised for overcoming some of the most difficult mechanical questions which existed in the early constructions of small motors. I do not know but that the main reason why the Gramme ring was not used for small motors at an earlier date was the fact that the armatures could not be wound cheaply enough to answer the purpose. They had to thread the wire in through this little ring and out again by hand; and the method adopted by the C. and C. Company has certainly overcome that difficulty in a very nice way. I think that in overcoming that difficulty they have started in on a motor and on a theory, viz.: that small motors can be built just as efficiently as large motors,—and there is hardly any reason why they should not,—which if carried out will bring success. But yet, if the analogy can be carried out, we all know that small steam-engines cannot be built to operate as efficiently as large steam-engines.

THE CHAIRMAN: I think that if fifty years ago, somebody had said to a Geneva or London watch-maker, that in the years 1884 to 1886, watches could be made so cheaply that dealers could give a Waterbury watch with $12.00 worth of clothing, they would have thought it was practically impossible. Certainly the price at which they make and sell these motors would indicate that perhaps further on they would be able to give them to some of these clothing dealers so that they can give a motor for every $25.00 worth of clothing, anyhow.

We would be very glad to hear from Mr. Wing, in regard to the application of motors.

MR. WING:—I would prefer to listen a little longer and to ask a few questions before undertaking to address the meeting at length. One of them is the question of batteries—primary or secondary or any other kind. Are there any persons here prepared to answer as to any of the existing batteries being practicable for long periods of time, so that the purchaser of a small motor can afford to run it? I have investigated quite a number, and

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so far, none of them have proved satisfactory. I would limit the question to three horse-power—one horse-power will do. If I sell a sewing machine or a fan or a lathe or anything else, I want to know commercially how long I can guarantee that battery to run and how much it will cost to run it per day, per week or per month.

MR. BRADLEY:—I have experimented considerably with a certain line of storage batteries. The storage batteries which I have worked upon are bromide of zinc and there have been certain difficulties to overcome in order to make them practicable. I never have placed them on the market. Of course this battery is very different from a lead battery, being free from some of the difficulties that are involved in a lead battery. But the specific resistance of the liquid is pretty high, which makes it rather inefficient unless the liquid spaces are very thin.

MR. WHEELER:—I might perhaps give you some figures about the batteries we are making; but I think on points of exact science, the cost of running them, etc., I should refer you to Mr. Crocker, who is one of the chemical experts of the company, and who has more figures in his head than I have. I might say, however, that our battery is an electropoion battery; no porous cup. Instead of using carbon plates, we use pencils. We use the regular electropoion fluid, except that it is a solid—here (exhibiting), is some of the material, and if we add pure water to that and analyze the solution, we will get almost exactly what electrical dealers call electropoion fluid. We use no larger jars than in a Bunsen battery. The amount of chemical energy in this solution is just the same as it is in the same volume of the ordinary electropoion fluid.

MR. WING:—I have found this difficulty in all those batteries with which I have experimented, that when you come to take them up commercially, there is the inconvenience of emptying the jars and replacing them.

MR. WHEELER:—It is giving that point due consideration which has led this company to produce a battery jar, which has a very suspicious appearance—(exhibiting jar). As that has about a tenth of a horse-power hour in it, I do not want to upset it.

MR. MAILLOUX:—How many sewing-machine hours has it?

MR. WHEELER:—It has about six sewing-machine hours. The electro-motive force is three and nine-tenths volts; the internal resistance is about 5-100 of an ohm, when you begin to use, up

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to about 15-100 of an ohm when the solution is mixed up with the acids of the action and when the resistance is therefore higher. The fair average is about 1-10 of an ohm internal resistance and the capacity of the battery is 12 amperes. It will keep on furnishing 12 amperes without declining until the chemicals are all used up. If you short-circuit the battery it will give more amperes than any other battery of equal size that I have ever seen. I have an amperemeter that will measure up to 45 amperes and it will give more amperes than that will register. It will give about 50 amperes on a short circuit. Of course it won't keep that up more than three or four minutes, because the solution will not circulate fast enough to bring fresh material up to the zinc in time. It will stand 20 amperes for five or ten minutes, but it will stand 10 amperes and trot right along without minding it at all. It does not furnish 12 amperes to run a sewing-machine for six hours, because a motor when running a sewing-machine will use only about 8½ amperes. Of course the resistance of the motor alone, without any counter E. M. F. will allow about three times that amount to flow. It takes two of these jars to run a motor at a lively rate and do work; one will run the motor alone.

MR. WING:—Suppose you want to run five or six hours during the day and eight or ten hours at night; how many cells would it be necessary to have, and how long would these cells last without replenishing? I do not mean to run right down to the hour.

MR. WHEELER:—Do you mean continuous running? You know if you give the machine to a person it will be said that it is used continuously. The facts are that they sew for a minute; then they stop to shift the direction of their seam, etc., and the electricity is not used up. I have to make that distinction, because an absolutely continuous run is a very different thing from a human-being run, so to speak.

MR. WING:—I am getting at the actual run—four hours during the day and an eight hour run at night.

MR. WHEELER:—I think you would be obliged to have jars about twice the size of this. Of course, if you were not going to do the work at any greater rate than this, you could use the same solution and simply have larger jars. If I were going to do it, I should have another pair of jars ready and slip them in when the first were exhausted. It is only a question of having enough solution there to keep it up for that length of time.

MR. WING:—My experience is that I cannot sell a machine to

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run by these jars in the ordinary form for the simple reason that people have to change them too often and it is too much work to change them. In running a sewing machine, as Mr. Wheeler observes, they run a minute and then they do not run a minute, and sometimes do not run for ten minutes; but when you come to put this same motor upon a machine that requires continuous running it is a different thing. The fan is probably the worst thing you can put on to motor, because it is a dead pull from the time you start it. Now, we sell largely for that purpose, and they are required to run about four or five hours for office business. Many thousands could be sold for ventilation of private residences, sleeping-rooms and uses of that kind, if we could get a battery, or if we could get the power at a moderate price to run these motors during the sleeping hours—say eight or ten hours, but it must be a steady run.

MR. PENDLETON:—I think if a power circuit was established there would be no difficulty in running either a fan or sewing machine satisfactorily. At the present time you are obliged to do what you can with the best batteries in existence at the present day.

MR. WING:—I am told that there is a party in Brooklyn who thinks he has what is a primary and secondary battery, so that by a change of wire you can get what you want.

MR. PENDLETON:—If you were in the city of New York, I do not think there would be any difficulty in supplying you to-day with what you require. I guarantee that you could be fitted out to use secondary batteries with good results. The electro-motive force supplied is low enough, and you have merely got to create the proper facilities. The current is supplied from a dynamo and you can run anything from a C. and C. motor up to a ten horse-power.

MR. WING:—That covers a few blocks but we want to cover several states.

MR. PENDLETON:—The only way then is to give them proper encouragement to go further.

MR. CURTIS:—I think the kind of fans Mr. Wing refers to chiefly, are fans that require more than half a horse-power to drive them.

MR. WING:—No sir; a thousand could be sold for that purpose at about one-eighth to one-fourth horse-power for sleeping rooms. This motor has got the power for that purpose, as I can see from

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the speed at which it runs the fan here. One-eighth or one-fourth of a horse-power will do very well for sleeping-room purposes and thousands will be sold for that alone.

MR. CURTIS:—The power of one of these batteries is 1-40 to about 1-50 of a horse-power. Now if you want 1-10 of a horse-power you would require four to six of these batteries. A tenth of a horse-power on a small motor is a good deal more than you would expect. When we were running it here, we were running from the Edison circuit, and were taking about as much current as one of these lamps takes—we were taking a little more; we were taking about a tenth of a horse-power.

MR. WING:—A tenth of a horse-power is ample for the purpose I referred to.

MR. CURTIS:—The question is whether, somewhat less than a tenth would be enough.

MR. WING:—It would be for smaller rooms.

MR. CURTIS:—When we took up the problem we found that there was not any battery in the market which, unless we used a good many cells would give anything like the necessary current. Now, the only way to get the power out of that battery is by fulfilling two conditions. In the first place, it is necessary to have large plates so that you do not draw a heavy current from small surfaces. In addition to that, you cannot have a very low resistance. As soon as the resistance of the battery comes up, you have got to increase the number of cells. The resistance of one of these cells is only 1-20 of an ohm; which is ridiculously low for a battery of that size. There is no battery made to-day which is as low as 1-20 of an ohm per cell, except a very large plunge battery. Now the only battery which would take the place of this and that would give the same volts and amperes before we devised this, was something like a Bunsen battery or an ordinary plunge battery. The difficulty with the plunge battery was that it would not maintain the current; there was no circulation of the liquid; and then if we put the plates nearer together we could not maintain the action, and we had to stop and give it a rest and then start off again.

MR. WING:—That has been my experience with all that I have tested.

MR. CURTIS:—That is eminently the case in any form of battery where provision is not expressly made for circulation. In this battery we can get about one ampere from about a square inch of

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surface. You take a battery with a porous cell in it, or an ordinary plunge battery, and it will have perhaps 12 square inches to the half ampere. This battery will give from five to ten times as strong a current for a given area of zinc as any battery I know of. We seem to have got as near the limit of lowness of resistance as possible, because unless you can lower the specific resistance of solution, you cannot bring your plates any nearer; there is nothing intervening which you can take out and you have got the resistance as low as you can get it.

The only way in which you can get power enough out of this kind of battery to give you one-tenth of a horse-power is by adding cells or making larger cells. Now you can do that easily enough. But nevertheless it involves having the cells four times as large or having four times as many of them. Then the domestic conditions come in; perhaps you can use it, perhaps you cannot. There is no battery at all, that it is worth while talking about for one half a horse-power, entirely irrespective of the cost of solution. The solution is a costly thing anyway. Now that battery will give a fortieth of a horse-power continuously for six hours. That requires one change of solution, and one change of solution costs about thirty cents. So it costs thirty cents for six hours.

MR. WING:—When you come to put one-tenth of a horse-power on and run eight hours, it makes the service very expensive.

MR. CURTIS:—Well, there are wealthy people who do not care about the cost of solution so long as the battery is easy to take care of.

MR. WING:—But they are obliged to have so many that it is a serious objection.

MR. CURTIS:—There is no difficulty in obtaining all the power you want if the electric light circuits are there. We anticipate that all cities are going to have arc or incandescent circuits for domestic use and we propose to put our motors on those circuits. You can put one of these motors in the place of one of these lamps here, as we do now, and it will give you a tenth of a horse-power.

MR. WING:—Do you intend to build your motors for arc circuits?

MR. CURTIS:—Yes: we have some already built. They are boxed up to protect them—that is to protect the people outside of them from touching them and getting a shock.

MR. WING:—Do you require any resistance coils?

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MR. CURTIS:—We have a shunt which controls them. They have a multiple arc with a variable resistance.

MR. WHEELER:—In that box you can get the power from a wooden pulley and you cannot get killed.

MR. MAILLOUX:—In reality, the current given to the motor is merely the difference in potential between the two ends of the shunt?

MR. CURTIS:—Exactly. We have got, perhaps, forty or fifty horse-power going through the circuit and you cannot change that very much. Now we make these motors up to two or three horse-power.

MR. WING:—Have you already made them large?

MR. CURTIS:—We have made some. We are not quite satisfied about the commutators yet. But they give very satisfactory results. At present we propose to apply them especially to fan work.

MR. WING:—I have understood that you have already put some on the Brush circuits. Have you arranged with them as to charge?

MR. CURTIS:—In some of the cities we have.

MR. WING:—In New York?

MR. CURTIS:—No; I do not think we have arranged in New York yet. The Brush people are trying it now. Mr. McGrath, who is superintendent of the district in New York, is trying it for his own station. I believe he says that he thinks they are just what are wanted for their circuits.

MR. WHEELER:—Mr. McGrath reports fifty-five per cent. efficiency on his circuits with this motor.

MR. WING:—He told me they were prepared any time they had a motor that was satisfactory to them, to put it in; I understand that in Baltimore the Brush people have agreed to furnish power to the Baxter Motor Company at five dollars a month. They are doing it right along all the time—for one horse-power or ten little motors at the same rate. They are putting them in a great many places where they are using sewing-machines. They put a small motor on each machine.

MR. CURTIS:—I am not sure but what the Daft people furnish a horse-power at six dollars a month.

MR. WING:—I think they charge altogether so much a month. motor and all. At least that is the way they serve us.

MR. MARTIN:—In Philadelphia there are about two hundred

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motors on the Brush circuits, some Cleveland and some of them Edgerton. I think on an average they get about four dollars a month. Mr. Law is running about sixteen of them with the current of an arc lamp.

MR. MAILLOUX:—I have recently conducted some experiments with various forms of batteries and while engaged in investigating the new exciting liquid which has come into the market lately under the name of conquonbite, I used a battery which is made in Philadelphia by Partz, called the Partz Acid Gravity Battery. It is a square cell in which the carbon is placed on the bottom. The carbon has a corrugated surface. He has one form in which there is simply a zinc, as in the gravity cell. In the other form, he has a porous cup with the zinc inside, and I have found that when the liquid was at the lowest specific resistance possible, the total resistance of the cell, carefully measured, was as low as 1–100 of an ohm, and consequently anybody might think that you might obtain a very large volume of current; but unfortunately as soon as you close the circuit you find that there is only a very small current, comparatively speaking. You may get between five and ten amperes, but even that not for a great length of time, simply because you have the counter-electromotive force of polarization which immediately reduces the available electromotive force. I am told they are using these batteries with great success for dental purposes. They generally run them in series of three or four, they do not ask such a great rate of current for them and depend upon greater electromotive force to get the greater number of watts necessary. The cell is certainly a very convenient one, so far as construction goes, because it is so made that it will run without care and comparatively very little attention for months. There is a tube, a sort of perforated device which opens at the top through the cover, and the solution formed from a chromic salt, can be put in, as occasion requires, and all that is necessary is to add the chromic salt occasionally, and the battery will last practically until the zinc is pretty nearly worn out, without changing the fluid at all, until the solution becomes so charged with zinc that it is no longer expedient to run it. You could take out some of the top part, charged with zinc and replace it with sulphuric acid and water. I have not made any experiments with the battery using that liquid, and consequently I cannot tell how long it will last; but it occurred to me that it was a very convenient form of cell, particularly for in-door use, office work and places where the

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battery is to be tried for a certain length of time and where it is desired to have a battery that does not require much looking after. I succeeded in getting four amperes out of a conquonbite solution and I was led to reason from this that possibly the regular Partz solution would give a higher current; I think that I was told recently that Mr. Partz himself was using them a great deal for motors where the current was two to ten amperes continuously.

MR. CURTIS:—Dr. Partz tried it in my office and it would not maintain more than three.

MR. MAILLOUX:—That was because the porous cup has a higher internal resistance than the gravity.

MR. CURTIS:—This was a gravity bi-chromate battery. He used his bi-chromate which is exactly the same as ours. In fact, we have an interference in the Patent Office. It was anticipated by a French publication away back. We saw Dr. Partz and found what his dates were. He filed his application. We told him what this anticipation was and he said he guessed he would file his application; and I rather think he must have suggested to the examiner that there was this anticipation, because all the applications were withdrawn and we were obliged to strike out the most important claim: so I do not think anybody will get the patent.

MR. HAMILTON:—The battery which I have experimented with has been very low indeed—not in any case much over half an ampere—and I am sure that would not do to work your motors where you require eight.

MR. MARTIN:—Our worthy friend, Mr. Mailloux, has lately been investigating—as he investigates everything—the subject of secondary batteries. This month he lectures before the Franklin Institute on that very important subject. Now this whole motor question resolves itself into a question of current. If once we have the motor, the question comes where shall we derive the current to drive it. It is very apparent I think, from this discussion, that the day of the primary battery in driving motors is not a very long one. Where shall we get the current then? We can get it largely from the arc circuits; we can get it from the incandescent circuits. There are 700 to 1000 motors on arc circuits and a great many on incandescent circuits. Mr. Sprague, for instance, has a large number of small motors in Boston—25 or 30—running on the Edison three wire system. But in order to put motors into residences and have them running when people want them, you

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ought to have a current that is available all day long in a great variety of places. In order to get that current, it seems to me we must in the last resort, fall back on the secondary battery. Mr. Mailloux being in possession of some very important data on that subject, I think he might oblige us.

THE CHAIRMAN:—My own company has been preparing for a long time to put down conductors for electric-lighting and for power and for every other purpose, but the trouble seems to be that this subject is loaded with the mighty incubus of the underground sub-way commission, and they sit upon it. They keep out the motors. They do nothing for the public, but everything for themselves.

I should be very glad, as the rest of us I have no doubt would be, to hear Mr. Mailloux on the possible application of secondary batteries to the running of small motors.

MR. MAILLOUX:—I do not think I shall be able this evening to make myself very interesting on any subject, and I have given so much time to the storage battery lately in my efforts to study it and to arrive at an understanding of it, that I made it a point not to talk shop outside of business hours, and it has become almost a shop matter with me. I think that the discussion of the motor itself is full enough of interest to take up the time of the whole meeting. There are very many features about small motors worthy of a great deal of attention; one is the efficiency of small motors. We have all been educated somewhat to look at the efficiency of a small motor as being necessarily low, but that is simply because we have not learned to dissociate the various factors of efficiency, We must first determine what we mean by efficiency—whether we shall indicate by that term the absolute efficiency of the machine, or merely its efficiency to convert mechanical energy into electrical energy or vice versa. The point I wish to emphasize particularly, is this, that while a motor may be very small and have a very small mechanical efficiency—a small co-efficient conversion—that is to say, its power to convert electrical energy into mechanical energy may be comparatively small when compared to a machine of much larger dimensions, yet the total efficiency may still remain at quite a respectable figure. When used as a generator it would convert a small proportion of energy of one kind into energy of another, but the total efficiency is not affected by that; it is the product of the electrical efficiency in the circuit, and the efficiency of the machine

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itself. Consequently if your motor efficiency is lower, then you have only to raise the electrical efficiency in order to have still a total efficiency which shall be equal in any case. In saying this, I have reference more particularly to tests made by various authorities, such as Ayrton and Perry, and Prof. Anthony and Lieut. Duncan, and others, in which they have shown very low total efficiency for small motors; I think in some cases as low as 13 per cent. of the total energy and in no case above 50 per cent. Now I have believed that they were not giving the motor a fair shake. The instrument from the necessary complications and limitation of its construction—it being of a small size, would be a very poor instrument to convert energy, so that its own co-efficient of conversion would be very low; (I use the words co-efficient of conversion, because I think it expresses the idea exactly); that is to say, the ratio of energy that this machine can transform. Yet, although its efficiency may be very low, the efficiency of the circuit is entirely independent, and that is the ratio of the total amount of work being done. It is a function of the total amount of work that is being done in any case. In any electrical circuit the efficiency of energy transmitted varies as the counter-electromotive force. It is a ratio of the counter-electromotive force to the total electromotive force. Let us suppose that this machine when used will transform 80 per cent. of the mechanical energy applied to it into electrical energy. Let us suppose, further, that 90 per cent. or 95 per cent. will be useful in the external circuit; so we have a total co-efficient of useful conversion of eighty times 95, which is 76 per cent. Now that is the co-efficient of conversion so far as useful effect is concerned. Now let us suppose that we have a battery so arranged that it will allow this motor to run at as high a speed as possible, and that we get the power out of it when it is running at 1,500 revolutions. Let us suppose that the current is as small as is consistent with getting the power.

MR. CURTIS:—Excuse me. It is the resistance of the motor that determines that thing.

MR. MAILLOUX:—Not necessarily.

MR. CURTIS:—You are running your counter up just as near your direct as you can. Now it is that resistance that determines the amount of current.

MR. MAILLOUX:—No; it is the total electromotive force you are using in the first place. If you are using a large total electromotive force, then your motor can give a higher electro-motive

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force, consequently it will develop a larger counter-electro-motive force, and the ratio of the two would be large. Now the total work that will be given to that motor may be anything you please. Let us take the case of the Edison circuit. This machine can be wound so as to give comparatively a high counter electro-motive force and we can make the ratio as high as we please and get the same power with a much lower current, and I find he uses current of about half of an ampere.

MR. CURTIS:—Eight-tenths.

MR. MAILLOUX:—Eight-tenths of an ampere. Very well. Now this would show that the counter-electro-motive force of the instrument would be a higher ratio and we may easily see that you cannot get 90 per cent. electrical efficiency. In other words the amount of the electrical energy that is required to transform to the moving part in proportion to the amount that is absorbed in the moving part itself is the ratio of counter-electro-motive force. Therefore the electrical efficiency will be anything you please according to the speed with which the motor is run. Consequently the total efficiency will be 76 times 90, which is a little over 60 per cent. That is what I mean to say—that although this may have a very low conversion, yet by raising its electrical efficiency, we can raise the total efficiency.

MR. CURTIS:—What is called commercial efficiency is the same thing as what you mean, taking into account the external and internal resistance in the machine. Take an ordinary dynamo machine—it does not affect the converting power, whether it has a high internal resistance or low internal resistance. In regard to the amount of current that it is necessary to supply it with in order to obtain a given power, that element is of no importance at all; nobody cares what the internal resistance is. The only trouble about having high internal resistance is that it absorbes the power, and then it prevents self-regulation. There is a great deal of talk about commercial efficiency. The most important thing is just the converting power. If you put 100 volts and $\frac{3}{10}$ of an ampere on that wire, then put on the friction brake and take out the foot-pounds, the proportion of friction that goes out to the amperes that go in gives the important thing as regards efficiency. The other important thing is how many dollars of ampere it takes to give an eighth of a horse-power or a tenth of a horse-power or two horse-power, whatever you want.

MR. CROCKER:—There are two efficiencies, only, necessary to

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be considered. One is the theoretical or electrical efficiency; the other is the commercial or net efficiency. Now there is nothing ambiguous about any of those terms. The theoretical efficiency means what Mr. Mailloux calls the co-efficient of conversion; that is, its efficiency as an electrical instrument. That is its efficiency which is interesting to a physicist as being the efficiency of an electrical instrument. Then coming to the question which is interesting to the man who pays his electric-light bills—how much of that electricity that is produced by that instrument gets into his lamps? That is the commercial efficiency. In either case there may be any fraction less than 100 per cent. Take the case of a dynamo. We put into it 100 units of work—energy. Now that dynamo converts 90 units [I use round numbers to facilitate multiplication] into electricity, in that instrument or outside of it—anywhere. Now that dynamo delivers to the consumer 90 per cent. of that 90 per cent., which is 81 per cent. commercial efficiency or net efficiency. Now it seem to me that without much mathematics that thing is very simple. I do not see any use in considering in a general way anything but those two efficiencies. Their names are not ambiguous—the electrical efficiency or theoretical efficiency and the commercial efficiency or net efficiency.

Mr. Wetzler:—I rise to a point regarding efficiency, not theoretical, but in a practical sense. I would like to call attention to a fact in regard to the construction of the armature of a motor. I am acquainted with a very well-known electrician who has started out to make a small motor of large efficiency—one which should approach the efficiency of the larger motors. He started out with a solid armature of the Siemens type. He got, I believe, 15 or 20 per cent. He tried all sorts of winding, etc. It occured to him that it might be well to laminate that armature, which he did to a certain extent, and he obtained 10 to 20 per cent. more efficiency. He kept on increasing the number of laminations un til he reached 60 per cent. Consequently I would like to point out that the efficiency of a small motor must be looked for to a considerable extent in the lamination of the armature. I see in the armature before me that the attempt has been made; but it strikes me that it could be improved upon—if the suggestion is allowable. It seems to me that there may be some chance of the current getting across these sections.

Mr. Curtis:—We made one test. We mounted one of those rings on a wooden block, without any winding on the armature

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and ran it at a high speed, and we found that whether you turned the field on and off or not—that is whether it was revolving in the magnetic field or not, made only a very small difference, and that was with an armature in which the lamniations were only half as thin as they are there.

MR. WETZLER:—You had no windings on that at all.

MT. CURTIS:—No windings.

MR. WETZLER:—You cannot say then that the conditions were exactly alike. Did you ever try a solid core with your actual windings on it? That would be a crucial test.

MR. CURTIS:—No; that would be so vastly different from a solid core. Until you get up to a certain point the efficiency runs up very rapidly. Beyond that point the Foucault currents are so small that it does not pay to carry them much further. We considered the thing very carefully and I do not believe that there is over five per cent. lost at the very outside by Foucault currents.

MR. WETZLER:—You will also remember that some time ago Mr. Mordey pointed out distinctly that the loss from the motors was due to that very cause—the Foucault currents.

There is another point I want to bring up, and that is, don't you gentlemen consider it advisable to have some arrangement for reversing the motor? For many applications it is desirable that the motor should run in the opposite direction.

MR. WHEELER:—Do you mean momentary reversal?

MR. WETZLER:—To run a machine in either direction.

MR. WHEELER:—You can do that; you can change the field connection for one thing.

MR. WETZLER:—I mean having your motor on your lathe or work-table and being able to turn a switch or any other mechanism and having the motor run in the opposite direction.

MR. CURTIS:—We have not had any demand yet for such a machine, and the principal purpose that has occurred to us for that kind of thing is for use on a boat.

Mr. WETZLER:—I can see very well that there would be more than one application for that kind of motor. For instance, a dental lathe would require reversing.

MR. MARTIN:—Dentists have asked me if I knew of a motor of that type.

MR. CURTIS:—One point about these brushes is that they are arranged so that the armature can be turned in either direction without destroying the brush.

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MR. PENDLETON:—When I had the pleasure of meeting you here last month, the prominent subject of the evening seemed to be secondary batteries. With an experience probably second to but few in this country, in secondary batteries, I felt that the claims of 80 and 85 per cent. were so far beyond anything that I had realized, that, as a matter of courtesy, I avoided the subject entirely—that is, in speaking of the value of the accumulator. Now, the accumulator has great uses, in my opinion; but it will be wrong to claim any efficiency for it, of anything like 85 per cent. I would be perfectly satisfied to have a fair commercial—not theoretical—efficiency of 50 per cent., not that above 50 per cent. cannot be shown, because 60 and 65 per cent. can easily be shown by any expert. But where they are used roughly by uneducated help, 50 per cent. would be a good commercial yield. Now, with the electrical service from a central station, such as either the United States or the Edison circuits, any number of small motors could be regulated by means of a storage battery. The only matter to be provided against is the full charging of the storage battery in the circuit. Automatic devices to cut out and cut in and operate the motor from the storage battery are things that are already accomplished, though they have not yet been introduced. Some years ago I had a surgeon of this city make some experiments with an osteotome in my laboratory for the purpose of testing the power to be received from an accumulator, and for that purpose he brought down with him tibbæ feet bones, etc., and had his little saw attached to his surgical instrument which operated very satisfactorily; at least he said that he had never been able to get such results from any primary battery and he had spent several thousand dollars in trying to perfect a system suitable for his purposes. I noticed that his instrument got upon a dead point several times and I asked him how it was. He said it was the best he could find at the White Dental Manufacturing Company. I got a Griscom motor which is covered with an india-rubber shell on the outside and I furnished him with a motor which has attracted some little attention although it has never been put on the market to any extent. I have received letters from Paris in regard to the cut of it which was published in an electrical journal some years ago. That little motor fulfilled its purpose and it was simply the commutation of two brushes upon a three pole armature with the usual circuit, so that there was a continuous current through the two circuits of the armature and

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the polarities gave on the three-pole armature all the attraction and repulsion that was capable of being derived. I finally conceived that it would be a benefit to use discs of thin iron, and my experience in the matter fully coincides with the remarks made here to-night. There was a gain in efficiency of at least 25 per cent. merely from replacing the cast-iron with wrought-iron. In regard to the loss by Foucault currents mentioned here to-night, this ring, traveling in the periphery of the armature, would not suffer from Foucault currents as much as the ordinary armature which is placed directly upon the shaft and having the speed of the periphery so much higher than the iron near the shaft. In that respect I should hardly think that 65 per cent. would be an overestimate for that reason; whereas in the ordinary H armature, it would be very much greater. As to the matter of insulation, an insulation by peroxidizing this iron, might be quite sufficient.

These little motors are becoming very interesting and their importance will be appreciated as soon as we can get the current to introduce them generally, and when that time comes do not forget that the secondary battery will be a most valuable apparatus to regulate and govern those motors and economize at the same time the power which will be lost in any other methods of governing.

THE CHAIRMAN:—It seems to me that this subject of street car traction by means of storage batteries is an important one. It may be, however, that the subject will be worth our consideration at the next meeting and perhaps some papers on the subject may be invited for a future occasion.

In regard to the core of this small motor and the oxidation of these plates—I suppose what he speaks of is the equivalent of the Bauer-Barff process, and before I heard of that process I got some of the black oxide of iron—the magnetic oxide—and I had it ground as fine as flour. Now, that is distinctly magnetic in itself; but it seems to me that to treat these plates in that way would not produce the desired result. I have suggested that where you have plates or wires in bundles, in a magnetic core, either an induction core or any other—that a simple process of light tinning would answer all the purposes of insulation in this core. Suppose these plates before they were put together were lightly tinned and then sweated together, the question is whether that would not prevent the Foucault currents.

MR. CURTIS:—The Foucault currents are produced as a result

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of the conductivity—it is an electric conductivity as far as we know. We cannot see how it can be anything else, because as soon as you have a low enough resistance across there for the currents to be conducted from one lamina to the other, there will be a current generated in the iron just as well as in the copper wire outside.

MR. WETZLER:—I believe when Mr. Pendleton referred to the peroxidation of these plates he simply referred to the rusting of them. I have heard of a man who in order to decrease the effect of the Foucault currents, in building up an induction coil dipped his wires in acetic acid. By then bundling his wires he obtained a good insulation comparatively between the separate ones, and thus discharged the Foucault currents.

MR. PENDLETON:—I did not mean the rusting of the iron, although that is a good insulation. I am speaking of the black peroxide which is known to be as good an insulation as rust itself.

THE CHAIRMAN:—You know in the experiments of House on the magnetization of iron, that that magnetization was found of different degrees, as the iron was laminated from the surface; and it occurs to me that there is more in the distribution of magnetism under the influence of an electric current through solid bodies and bodies that are divided up by a non-magnetic material than perhaps has been brought out and demonstrated practically. It has got to be beyond ten o'clock and perhaps it is time for us now to adjourn. I think we have all been interested in the discussion this evening and in the beautiful manner in which this motor has been exhibited and its efficiency demonstrated.

The meeting then adjourned.

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DISTRIBUTION OF ELECTRICITY BY SECONDARY GENERATORS.

Special Meeting.

March 15th, 1887.

The special meeting for the consideration of the subject of distribution of electricity by secondary generators, was held at 130 Broadway, New York, at 8 p. m., March 15th, 1887, the President, Mr. Frank L. Pope, in the chair.

The President:—Gentlemen of the Institute:—It affords me great pleasure to be able to meet with you once more. I had begun to think that I should not see you again for some time. I am glad to see so large an attendance.

The subject for discussion this evening is the "distribution of electricity by secondary generators." As you all know, the problem of the distribution of electricity for lighting, by induction apparatus, variously called secondary generators, transformers, converters, etc., is attracting a great deal of attention at the present time. It is not a particularly new thing, having been employed in one form or another pretty constantly since the early part of 1883, yet it is only quite recently that it has been brought into what may be properly termed a commercial condition.

Very many of you are doubtless aware, that something over a year ago I was commissioned by Mr. George Westinghouse, Jr. of Pittsburgh, now President of the Westinghouse Electric Company, to go to Europe and make an examination of this system, and if advisable to purchase some of the leading inventions for use in this country. Mr. Westinghouse had already made some experiments in that direction, and had become much interested in the future possibilities of the system. I went over to London in January, 1886, and had the pleasure of seeing there an installation of some twenty-five hundred lights working under the Gaulard and Gibbs patents, at that time the only important installation which had been made. I saw that there were great possibilities in the system, although it was not worked out in practice as we would

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work it out in this country, by any means; I was nevertheless so well satisfied with the results already attained, as well as of the possible results which we could get when we put our young men in this country at work on the details, that I closed the purchase of the Gaulard and Gibbs patents for Mr. Westinghouse. Up to that time the invention had not apparently attracted very much attention in this country; but during the past year a great deal of progress has been made and it certainly seems now to have a great future before it. Theoretically it is unquestionably a system of the utmost interest. There are many novel features embraced in it—novel in the sense that they have not been practically worked out and applied. The action of the induction coil is a great mystery to many people and is in fact not any too well understood by the best of us. My work in connection with the system has not been of a practical character, and in fact I have hardly an opportunity during the past year to examine any of the installations which have been put in.

Dr. Otto A. Moses:—What I have to say to-night on this subject of secondary distribution will not be of a very profound character, although from having seriously investigated the subject for sometime back, I might be inclined to treat it more precisely. I see, too, among the guests, one who I know would prefer to look at it from a thoroughly scientific standpoint. What I will say was suggested to me but an instant ago by the action of the incandescent lights which startled us by that sudden flicker. (Laughter). I would not have stood in the shoes of the man where that thing originated for something handsome. He must be in a profuse perspiration at the present moment. I think I see him tugging away at a brush, a long stream of fire issuing from it. There is a general gathering of the hive; and they are making every effort to stop it. They are loath to put their hands on the brushes, because any attempt to stop a sparking at the commutator may lead to further flickering of the lights. For that sparking is the weak point down there; and it seemed to come very opportunely for us just now to show one of the advantages in a secondary distribution.

In the secondary system, at present, electricity is distributed in alternating currents. Whatever violence there may be in changing the direction of a current of electricity, two hundred and fifty times a second, takes place in such a way as to be silent and invisible to us.

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The production and distribution of alternating currents is so simple a matter that the very first dynamo machine ever made was constructed on that principle. I recollect when Comte du Moncel told me of the consternation with which the people who were interested in the Alliance machine, came to him one day and said, "The thing won't decompose water," for which purpose it was being made. "Well," he said, "I don't see any other way to do than to make it decompose water by turning it into a machine with currents of one direction; but if it were my affair I would leave it an alternating machine. Why not use the current at once for making light instead of decomposing water with it in order to get light from the recomposition of its elements?" It was a very unfortunate thing that the alternating current machine did not decompose water, because we would have been about twenty years further in advance in the application of electrical science. That was the quietus of the alternating current machine for the time being. Well, they made a continuous current machine that decomposed water; but soon they found they could make light a great deal cheaper by that alternating current machine than by combining hydrogen and oxygen. The first alternating current machine they made I have seen working near Havre, in the lighthouse. It has never been stopped but once, and that was in order to put in a pillow block. No accident has happened to it, and it has been going on beautifully ever since. It was put in 1862 or 1863, I think. But it was a cumbersome machine. However, it was as smooth running and as strong as anything possibly can be. Now, the alternating current machine is so simple that it is a wonder to me that it did not continue in general use. But then there came another matter to give it a set back. M. Archereau, (a very pleasant man and very much of an inventive crank), discovered that a solenoid was a very excellent means of regulating a lamp. You could not use the alternating current with that. Therefore the whole stream of invention ran into the channel of continuous current machines, and from that moment continuous current machines were universally studied, because they could operate the regulating device of the ordinary solenoid arc lamp; and as the arc lighting business was the great one by which electricity was going to be built up as the power for general use, practical continuous current machines were invented and generally adopted. Now, when a thing once gets on the ways, sliding down like a ten thousand ton ship, you cannot stop it.

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It is bound to go, and when everybody's mind gets acting on a certain kind of improvement in a fundamental invention, it is bound to go on that route. Look at the Morse system. It is only quite recently that they began to take messages off by sound. No one would have thought of taking off messages by sound when I was a boy. Why? Because everybody did it by reading from the paper, and so everybody had to continue to do it. Such are the grooves in which the mind of man runs. The development of an invention is very much like forging a chain; one link has to be connected with the other until you get to the end of the chain. Then you may start another chain if you wish; it may be of different sized links and of different materials, but if you want to have that chain complete, its links must be of the same material and be pretty much of the same size. The invention of the Jablochkoff candle gave another stimulus to the alternating current machine; but popular prejudice, excited by the death of a careless sailor on a Russian royal yacht, caused its almost total abandonment for use in electric lighting; and finally the introduction of incandescent lightning on a great scale on continuous current circuits, made it disappear entirely from use.

But now the alternating current machine has taken a new and grand departure, because we find that you can only distribute currents by secondary generators where they are alternating in their character. Therefore, the alternating current machine has to be introduced, and its great advantages which were hidden, simply because they were not needed in the beginning, have come now to the front, and it will be adapted to all kinds of distribution of electrical power. That sounds like a pretty broad statement when we know that motors are being run on continuous current circuits. But what is the difficulty if you have got an alternating current machine that sends its currents to and fro? Why, usually you send it to and fro through the same point. You can send it *to* there, and you can send it *fro* here, and you can have all the continuous current you please on the one side, and all the continuous current you please on the other side. (Applause.) So that an alternating current machine can be made a continuous current one, and you can adapt the alternating current machine to any of the uses to which a continuous current machine is now applied.

Now, to come to the point, I would say that the practical application of this thing has been demonstrated to my satisfaction,

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and that is something that means to me a good deal. I think that alternating currents from secondary generators are going to drive all the small electric appliances for the distribution of power that are now used. Secondary generation is bringing about a change that is going to result finally in a commercial revolution. We will find currents distributed abroad in every direction, in every house, and we will have power at command for all purposes, just as we have it here at this moment in the incandescent lights around, and that is all going to come about through this alternating distribution.

I was in Pittsburgh the other day and saw such a system working, and it was very gratifying to one who has been through a good many of the mills of experiment. I had seen the first work done in incandescent lighting, and I know what the difficulties were and how long it took to overcome them all, except the one insurmountable difficulty to the distribution of that light by continuous currents over great areas; for the rapid increase in the size and weight of the conductors are a bar to the extension of a system of distribution beyond a narrow limit, where large quantities of current of low potential are to be consumed.

There is in Milan, Italy, a very large system of distribution of electric light, supplying some six or seven thousand incandescent lamps of this kind, from a central station. One of the owners and originators of that plant was Professor Colombe. You may have met that able gentleman when he was over here. He came to study the distribution in the city of New York, and he was so well pleased with it that he went back to Milan and started a successful central station there. He was subsequently appointed a Commissioner of the Turin Electrical Exhibition, when he was called upon to make an investigation of this very Gaulard and Gibbs matter; and although he was deeply interested in the central station there—the Edison central station—he in a published paper admitted that the method of distribution of currents of 100 volts potential was limited to an area of from 500 to 600 metres radius. Well, that figure in a distribution in a great city amounts to limiting it to an improbable point. All the influences in Paris so far brought to bear have not caused a central station to be established within the walls of that city, which would show that French capitalists believe that continuous currents with an electromotive force of 100 volts and thereabouts can only be profitably used for distributing power for lighting purposes within very

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small areas. Professor Colombe went further—although it was really against his own interest to say so; but, as one of the Commissioners of the Exposition, he said that the Gaulard and Gibbs method of secondary generation was going to solve the question of the bringing of power to and distributing it in a city. That is to say, in order to solve the question of electrical distribution you have to combine the bringing of alternating currents to local central stations and distribute them thence at lower potentials. He did not say anything about how you were going to transform the currents from alternating to continuous ones. He did not say it was desirable to do it; but he said it was a very necessary thing to bring in currents of high potential and to transform them into currents similar to those he had introduced into use in Milan. That statement came from a man whose entire interests were in other directions. Now, that is a very good way, by the bye, to judge of the value of an opinion. I have heard it once said by a lawyer (who was subsequently made a judge) that the true way to ascertain a man's merit is to see what his enemies give him credit for, because that he must have. Now, in his particular case, the merit of the Gaulard and Gibbs matter has been fully recognized by Professor Colombe (one of the best authorities in Europe) as the thing that is going to bring the current from outside a city to points within it of low potential distribution. I go a step further and say I do not see why it may not get there and then distribute itself, changing itself without the intermediation of a machine at the door of the consumer, into perfectly safe currents, as is done by the Westinghouse system of electric distribution. But, gentlemen, we must not delay any longer hearing what Captain Michaelis has to say. [Applause.]

Captain Michaelis:—I have very little to say. It happens that I am living at a place where some few friends of mine conceived the idea of starting an installation, and because they thought I knew something about guns and equipments, consequently I must know something about electricity; they spoke to me about it, and I thought it was time that I tried to learn something about it myself. You know that Marryatt has written a book called "Japhet in search of his Father," and I might write a book called "Michaelis in search of an Electric Light;" I think it might be worth reading. I have a great many friends in the Institute, all very nice gentlemen, and so I thought I would see my friends first. They treated me very kindly; took me to the Astor House, Del-

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monico's, Cable's, etc., and I began to get bewildered. All the lights were good and I did not know what to advise.

In the course of my wanderings, I struck a little hill town, pretty nearly a thousand miles from here, with not quite 5,000 inhabitants. I was provided with half a dozen letters to the electricians of the place. I arrived there one Sunday afternoon. Unfortunately the gentlemen to whom I had letters were absent. I hobnobbed with one of the men of the town whom I met at the hotel. We were searching for the same thing. It was not an electric light, however, in this case. (Laughter.) We became acquainted and I found that he was one of the stockholders in the electric light company of the place. He took me to his store and opened it, and I spent a couple of hours with him and I obtained a good deal of information that I thought would be of interest to my friend who had spoken to me, and I think it has proved so. Now, this little town is way up in the hills. It has less than five thousand inhabitants; there is not a single prevailing industry in the place. It is a little country town. I arrived there Sunday afternoon at four o'clock and the first thing that struck me was that the town was peculiarly lighted up. It was the first experience I had of this peculiar illumination. It was natural gas. I asked my friend what he paid for this light. He said fifty cents a month. I concluded electricity could not compete with that. I asked him if they had any gas there. He said that they had a gas company that had been charging three dollars a thousand, but they had put it down to $1.90 since this new light had come in. I asked, what have you got in the way of electricity? He then showed me the electric lighting system. He took me to their plant and I was much struck by it. It was a business looking place. There was nothing that was not needed and everything that was required was in its proper place. I asked: What did this cost you? He told me they had formed a lighting company with a capital of $15,000. They had a 600 or 650 light plant. They had purchased the ground on which the building stood and had paid all their expenses and had just about exhausted their capital. It was a sort of co-partnership; all the lights were subscribed for. The large room at the hotel where we met originally, which I suppose was perhaps 40 x 40, was well lighted with six 16 candle power lamps. I went to other places and was delighted with the illumination. One subscriber might say, "I do not use this light so much as another," and they would charge him so

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much less. I calculated that the average commercial light was sold for $8 per year. That gave them an income of $5,000. I footed up the cost of their services and expenses and I found it to amount to about $2,000 a year. I must say however that the coal was very cheap. They were only paying four cents a bushel for it. Now, this gentleman not being an electrician, I must confess, that you cannot rely upon his figures; but they had made, according to his figures, about twenty per cent. on their capital. Now, I do not wish to advertise any company, I do not even like to say where this place is, but I think, Mr. President, that this is a matter which is encouraging to all electric light companies. Perhaps it was a fortunate accident for this special company that it had its plant there. Still, in answer to inquiries I hear, I have no objection to telling you that the town was the city of Greensburgh in the mountains of Pennsylvania, and that the company that put in the plant was the Westinghouse Electric Light Company of Pittsburgh. (Applause.)

PROFESSOR ELIHU THOMSON:—Mr. President and Gentlemen: This is the first opportunity I have had of meeting the members of the Institute, and I am very glad that I came down. On former occasions I have been entirely too busy and pre-engaged to make it convenient to leave the place where we carry on most of our operations.

The subject for discussion this evening is one of very great and growing importance. I am forced to recall a little experiment I made, in illustration of the reversibility of an induction coil, before the Franklin Institute of Philadelphia, in 1877. I then gave a course of lectures on electricity; and the main principle put forth was that electricity of all kinds and characters—statical, dynamical or whatever you choose to name it, was really the same thing and of exactly the same nature, differing only in potential, pressure or electro-motive force and volume. I exhibited, of course, in illustration of this, Rhumkorff's coil; and while preparing the lecture it struck me that it would be a pretty experiment if I could reverse the process, and instead of getting discharges which would have the statical properties, I should take my Leyden jars and put the Leyden jar discharge through the fine wire of the Rhumkorff coil and see what I would get in the primary circuit. This I did, and I was somewhat astonished at the volume of current which seemed to come out of the primary. I expected, of course, to get a heavy current. I knew perfectly well that the

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Rhumkorff coil must be reversible, but I was surprised to see the energy that the Leyden jar discharge displayed when it was turned into what was then called the quantity current; the ends of the primary wire being brought together, there was a bright green flash, and after repeating the experiment once or twice the wires actually stuck firmly together. It was with difficulty that I separated them. They bent a little, and with a good pull they separated. There was a sufficient proof of the reversibility of the induction coil. The capacity of the Leyden jars was three gallons. The spark which fused the coil was an inch and a quarter long. Another fact came out in the experiment which was very striking. We are all familiar with the loud snap produced by the Leyden jar discharge and the bright flash. I was surprised to see, however, that the spark which struck through the coil was exactly like the Rhumkorff spark. It occupied a time. It didn't go with that sudden energy with which the Leyden jar discharged, but it went through with the appearance of the ordinary Rhumkorff spark. This thinning out was no doubt due to the retardation which occurred in that discharge. That is, a portion of the current started out first—for we must in that case call the Leyden jar discharge a current, even though it may last a billionth of a second. It passed through, as I say, in the character of a Rhumkorff spark, and the primary current seemed also to last for the same length of time. This experiment was repeated and the primary wire was also connected with a galvanometer of very coarse wire and the needle went right up solidly to the stop at every Leyden jar discharge. At that time I thought it must be perfectly well known to anybody who would dwell upon the conditions.

This experiment left its impression on my mind; and my recent experiments in welding by electricity are really the outgrowth, as I see it, of that little experiment of the Leyden jar discharge sent through the Rhumkorff coil.

When engaged in electric lighting, I found it necessary, in the construction of dynamos, to make good joints on wire and it was with some difficulty that really good joints were made. Our wire in the early days was only obtainable in about fifty pound lengths of copper—and some of our coils required about 300 pounds—so that we had to make some five to six joints in every coil. This necessitated, of course, great care on the part of the man making the joints and he was oftentimes liable to make slips

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which would not even allow the wire to be bent to and fro. In thinking the matter over, it struck me that electricity would do that work, but the thing was to get the currents. They were necessarily enormous. They were necessarily much larger than we had been accustomed to deal with. Arc light currents and incandescent currents in those days probably did not in any case give more than two or three hundred or four or five hundred amperes. The machinery had not been developed to an extent beyond that. The induction coil experiment, however, seemed to point out the way, and I designed at that time an apparatus which I thought would answer the purpose, but I was compelled to lay the affair away and had no time to develop it further. Taking it up finally, however, I tried the experiment of building a small alternating machine and putting on it a moderately fine wire, which was to be the primary, and taking a very coarse and heavy secondary, so that the potential of the currents generated in the secondary might not exceed one or two volts at the most, but could run up to thousands of amperes. The first experiments made with the apparatus were entirely successful in joining copper, iron, steel, etc., the wires being a moderate size of course. I mention these facts simply to show their connection with the subject under discussion. We have there probably the extremest case of what we call conversion from high potential to low potential. Dr. Moses has mentioned the fact that no commutators are needed on the alternator; and I can say that it was really fortunate for us in welding operations that there are none, because our currents are varied enormously in a very short time. We start out with a piece of metal that probably has only a few square mils in section and the same apparatus we run up to an inch or more in diameter, and if we had a commutator on the machine that amounted to anything, we of course would have to make a new adjustment each time, and every time the current changed greatly it would be very likely to tear out the metal and throw it around, because we run under strong conditions while we are putting on the heaviest gushes of current.

As to the distribution of incandescent lights by the induction coil, I may say that, in the latter part of 1878 and 1879, in company with Professor Houston, I made some experiments with the design of using a little arc lamp for distributions. It is called a vibration lamp. The electrodes were vibrated to and from each other and we used induction coils to give the impulses to vibrate the carbons and also to supply the current to the little lamps. The

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incandescent lamp in those days was unknown. There was no such thing as incandescent lamps in 1878, at the time the experiment was made, but gradually the incandescent lamps became known, and the induction again began to attract some notice in regard to use in distribution. Now it always has appeared to me that there never could be any doubt as to the efficiency of a good induction coil; that is, that the losses in an induction coil never could amount to a great deal, if it were properly made. What is a dynamo machine but an induction coil after all? It is a revolving induction coil. We have what might be called the primary circuit in the field magnets, in the magnetism; but instead of reversing the current in the field magnets we reverse the position of the secondary, that is we turn it over to get our impulse, not that those impulses came out as gushes of current or waves; but if we turn over portions of the armature by degrees, we get a continuous even flow of current, and if the dynamo can be made to reach an efficiency of 90 per cent., why cannot an induction coil be made to go to an efficiency of 95 per cent? [Applause.] We use a reversed primary. We do not reverse the position of our armature in relation to the magnetic field developed by the field magnets; but we make our field magnets reverse and divide them up by laminations or by making them of fine iron wire; put plenty of iron in the coil and the losses should not be any more in making the conversion, so far as Foucault currents or local currents in the iron are concerned, then they are in a well constructed, laminated armature.

In regard to the use of alternating currents, let use see if there is any possible objection to the use of them. There has been a great prejudice against alternating currents, (which I think has gradually been removed) on account of the very fact that they alternate and that they are not without the danger of severe shocks. We have learned to look upon alternating currents, somehow, with considerable dread on account of the fact that the current goes this way and that. I had some early experience in that respect. Most of you probably have heard of the Jablochkoff kaolin light, in which the induction coil was used to throw discharges over a piece of kaolin, only the discharges were of high potential, produced by low potential currents. The electrodes were drawn over the kaolin and a very pretty light, of a moderate intensity was produced. It was in experimenting on this subject that I managed to get hold of the ends of the induction coil. To

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say that I was surprised would not express the conditions at all. Professor Houston, who was present, said that I jumped into the air about three feet, and in doing so I broke away from the wires, but for a moment I felt that if the thing continued a few seconds there would be no more of me. I did not feel it anywhere but in my head, and it seemed as if a thousand cork-screws had beeen sent in from all sides to mix up matters internally. However, the wires were not very strong and I broke away very easily. The shock was probably severe, but the potential was such that the discharge could jump through three-eighths of an inch of clear air and the wire of the induction coil was not so very fine, but that considerable current could flow. The potential was enormous. Now, the other day in experimenting with alternating currents in which the maximum difference of potential existing was about 1,300 volts, capable of equalling in potential a good circuit of arc lamps, I happened to touch a post and bring my hand to another post, and I felt something or other queer and drew away. The result was, I got a little blister on the hand, but that was all. If I had short circuited an arc current of the same power I would not have got away so easily. I should have come away with my hand very badly burned. But as it was, the alternating current spark did not follow up as I ruptured the contact. That is a feature of the alternating currents which is very useful in rendering them safe. Let us see if we can find any reason for it. The alternating currents rise and they come down to zero, and they reverse and so on; but there is a line along the middle of the curve which is neutral. Now, unless the materials are of very high volatility, the spark formed is very apt to be extinguished on that reversing point. At the same time there is another fact which would cause that arc to be extinguished, and it is that the effects of self-induction or extra currents in prolonging the discharge are nothing. Take an alternating current, and in its changes it cannot follow up anything that has short circuited the apparatus. It would seem from these experiences that we need not have any great fear of the danger arising from alternating currents.

It is very doubtful indeed whether the fluctuations in the arc light current are not quite as great and whether the injury to a person short-circuiting an arc light current is not due as much to abrupt changes in the current as to the mere current itself. That is, an arc light current does not usually have the character of an

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even wave—a smooth wave. There are segments in the commutator acting just like so many break-pieces and whatever effect they produce is produced in an inconceivably short space of time; and if we could map the waves of a current they would be found very irregular and ragged. No doubt every one has tried the effect of a shock from a magneto-electric machine. Everyone knows that if the speed is regular and the contacts are good he can stand a pretty fair shock; but let it be irregular, let some faulty condition occur and give him a shock, and then ease up a little and give him some more and it will be found to be very exhausting indeed. In the one case he knows what to expect and is prepared for it; in the other he is not. This brings us up to the consideration of the nature of the alternating current itself. It is a ryhthmic wave, and it can be made so perfect and so smooth that at any portion of the wave the change of current is quite slight. There is not a sudden jump of current or a sudden action which though it occupy only the ten thousandth part of a second will make a considerable difference in the wave. Let us see whether we have any facts which would lead us to think that there is a difference of that kind between the ordinary arc light and the alternating current. In working on this alternating current matter, it occurred to us that there might be some difficulty in running lines on account of telephone interference. Injunctions might be served on anybody running lines, if the alternating currents had a bad effect on the telephone lines. To test that matter we ran parallel telephone lines to an alternating circuit, and to the arc light circuit using about the same current on each, and I was surprised at the results. The alternating current line did not give us any induction in the telephone while we had about fifty feet or more parallel and the arc light current gave us a strong induction—a rattling, scraping sound; and when I thought of it, it all came very clearly. At every segment of the commutator, there was a little break, just as quick as it could be made. A difference was produced in the telephone circuit so sudden that it was bound to produce a wave that would shake the diaphragm,—a kind of scratching, irregular sound, nothing melodious about it. Then we arranged the conditions so that we could get induction from the alternating current alone to the telephone line by increasing the length and coiling the wire a little and gradually we could hear the hum of the alternator; but it was music compared to the other. It was a musical tone; you could talk through it and not be both-

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ered by it in the least. It is doubtful, as one of our men suggested, whether we could not, in case we had difficulty, play a tune; that is, we could send chords over the line by sending impulses the right way, so as to make everybody happy. I do not say that all alternating currents are of that character; but I do think that there is no difficulty whatever in constructing machines which will give waves that are very easy, regular, and just as perfect as you could have the waves produced by a fine tuning-fork, without any of the abrupt changes. Now I have no doubt that in the construction of alternating current machines, in which there are irregular changes in the magnetic circuits quickly effected, that the impulses would be harsh and rough. But if these changes are smooth and gradual, there is no reason why the sound produced n telephones by induction should not be very smooth and melodious, rather than disagreeable. [Applause.]

THE PRESIDENT:—I am sure we have all listened with a great deal of pleasure and derived no small share of profit from the remarks of Professor Thomson, and although not wholly in the line of the subject announced for the evening, we are more than pleased to hear from him something about the origin of his discovery of the process of welding of metals by electricity. I happened to be in London at the time the discovery was announced. A cable dispatch of ten or fifteen words was published which created a genuine sensation among the electrical and metal people; and although by this time some of them have doubtless discovered that it is not true, and others that everybody knew it before, I heard very little of that sort of talk at the time.

Professor Thomson has called attention to the resemblances between the induction coil and the dynamo. These resemblances which he has illustrated so beautifully, need to be better understood than they are. The induction coil, as he has shown us, is nothing in the world but a stationary dynamo, in which the poles are moved within the mass of the iron instead of the iron being moved bodily. Hence it is very plain, as he says, that we ought to get a higher percentage of efficiency from a properly constructed induction coil than from the most perfectly constructed dynamo; because the mechanical difficulties that we meet with in providing for the rotation of the armature are eliminated. We can bring the parts into closer relation with each other, and in that way we necessarily increase the efficiency.

In regard to the remark which Professor Thomson made re-

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specting interference with the telephone. I was told in London that a circuit was originally run there some six miles in length, (the primary circuit of the Gaulard and Gibbs system) a rectangular loop embracing eight or ten blocks, and that the commotion which was created in the telephone exchanges by induction from the alternating current was something frightful. Injunctions were applied for, and there was a great controversy. Finally, after some discussion the circuit was arranged in the form of a double loop; that is the loop was formed into a sort of crescent, the wire out and back being carried on the same supports all the way. That immediately removed the disturbance; you can scarcely hear the slightest trace of it in the telephone now, although the lines go through the same neighborhood. The fact is that the currents of the circuit out and home seem to neutralize each other, or at any rate they are effectually neutralized. The induction does not get into the telephones. I would like to hear whether Mr. Wetzler has anything to say about this.

MR. WETZLER:—I do not know that I can enlighten you very much on this subject, but it strikes me that the point of utilizing a high potential current of low quantity for the purpose of facilitating distribution is one which can be looked upon in another light; that is to say, we may use a continuous current and interrupt it. The arc current to-day may be considered in that light. We have there the conditions of a high potential circuit with low quantity. Why may we not by suitable apparatus break that current at certain points, utilize it to put our secondary generators in operation and then continue it on; or, if you will, break it directly at a central station and use the broken continuous current (if you might so call it) in the same way as you would the alternating current? That system has been brought out recently and I think it presents some considerations worthy of notice.

We have all heard of the advantages and also of some disadvantages of the secondary generator system in this country as presented here. I think it may interest the members to hear the opinions of some foreign electricians on this subject. Dr. Moses has given us Professor Colombe's opinion, which is very favorable; and I think, for the sake of discussion, that some of the unfavorable opinions might be brought forward. In a pamphlet recently issued by Messrs. Siemens of Berlin, they flatly contradict the utility of the secondary generator system. They say in effect, that isolated installations, even large ones, are practicable on this

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system, as witness some of the installations already existing in Europe. These they consider, however, only isolated systems, though on a large scale. For a general distribution they claim that the thing is not feasible, in fact is not as good as the ordinary two-wire direct distribution. I must say this, however, that they premise that all distribution must be done by underground conductors. They say that if you want to distribute generally, an overhead system will not accomplish the result; that there are too many uncertainties in connection with it and that you must go underground. Now they figure up that to put underground a high potential system, in which instead of using 100 volts ordinarily, you use two thousand volts, with a corresponding reduction in copper; the money you save and interest on that copper will not make a difference of one per cent. in your running expenses. They say that the copper in the conductors underground is but a very small item in their expenses; that the insulation on the conductors costs a great deal more and is almost equal to the cost of copper, no matter what the size of your conductor is, and that what you gain in conductor you will loose in insulator. Then, of course, they bring out the usual argument against the alternating current not being available for motors, which they consider an adjunct for electrical distribution. Now, how far these objections are good, or how far they can be removed remains to be seen. I think they can be removed; if they are not removed already. But such is the opinion of Siemens, which has some weight, whatever his motives may be. He also says that you cannot regulate your secondary generator within the limits; that it must be regulated to give satisfactory incandescent lighting. He says if a secondary generator will regulate within four per cent. when turning on all the light, that that is not sufficient, and that secondary generators cannot regulate closer than four per cent. I believe that that objection can be removed if it exists.

THE PRESIDENT:—I would say in respect to one point raised by Mr. Siemens that it is not quite clear to me, since a secondary generator is nothing more than a dynamo—why it is not possible to regulate with such a generator as it is with a direct distribution.

MR. WETZLER:—Siemens in his pamphlet criticises other systems; but he says that he has got something that will regulate it.

MR. MAILLOUX:—There is one point in Professor Thomson's remarks, which interested me very much and I see that our worthy president has also referred to it; that is the analogy between the

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dynamo electric machine and the induction coil. In the discussions upon the subject of the secondary transformers before the Electrical Society at the last meeting, I dwelt rather at length on that very question; and just here I must say that I must differ somewhat in the manner in which I viewed the subject. It is undoubtedly true that ideally considered the dynamo electric machine is an instrument for producing alternating currents; that we only reverse them by means of a commutator; but it is not a transformer in the sense that it gives us energy of the same class as the energy we put into it. In the dynamo electric machine we employ mechanical energy and it gives us back electrical energy. At the electrical exhibition in 1884, I remember seeing something that greatly interested me, and that was an apparatus designed by Professor Thomson. It was a dynamo electric machine, in which there were two armatures; the inner had four cores and one of the armatures was wound with wire capable of standing the arc light current, it also having a commutator. The other armature had small collectors. There we have what I call a first class analogue of the induction coil; because we take electric energy of high potential and we transform it into electrical energy of low potential, so that the other analogy brought out by Professor Thomson is only true in the sense that all forms of energy are from the same source and that we transform mechanical energy which is of comparatively low potential into electrical energy of high potential, because energy of high potential as distinguished from energy of low potential merely means this, that in energy of low potential we have a small weight carried over a larger distance; whereas in energy of high potential, we have a large weight (or what is equivalent to it—a large pressure) doing work through a very small distance; so if we consider the energy of electricity due to the molecular action taking place in the wire, we can see that we have enormous pressures acting on very small masses. Now, if we revert to the analogy just stated we will readily see that we are taking energy of one potential from the arc light circuit and transforming it into energy of a lower potential, but of greater volume, and in each case the amount of energy converted can be estimated by the ratio of the electromotive forces. Professor Thomson states that the efficiency of an electrical dynamo machine being as high as 90 per cent. there is no reason why we should not have a higher efficiency even in the induction coils. Now that is true and I must permit myself here to point out one reason why, and

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that is this: in the secondary coil of the transformer we have practically no dead wires. That is an important distinction in all forms of dynamo. There is always some wire which is dead by reason of the fact that it is placed at the ends of the armature, or inside of it where it is not subjected to the action of lines of force. In an induction coil on the contrary every particle of the wire is placed in a magnetic field, and necessarily we must have a greater efficiency of transformation. In the dynamo machine we have now arrived at the point where we can tell pretty nearly the length of wire that will be necessary for one volt when the field is at its normal degree of saturation. I would like to know if any gentleman present has had experience enough to tell us whether he does not find that in an induction coil the same mean electromotive force will be obtained with shorter length of wire, the general conditions such as magnetic density, velocity of relative motion between lines of force and wire being of course taken alike.

With regard to the action of the telephone, I must say that the statements made by Professor Thomson brought to recollection some very interesting facts which have been in my mind for a long time. Last summer I was engaged in the investigation of some matters connected with the telephone, and I had occasion to look into the theory of telephonic action in general; I remember particularly going over the researches and experiments made by Mr. Van Rysselberghe in Europe, and there I found that he endeavors to prevent induction in telephonic lines by taking electric impulses and subjecting them to a process by which they become undulatory; he gives them that rhythm which Professor Thomson alludes to, and when he has done so, he finds that they become powerless to produce induction on telephone lines. The facts are well known, and to-day in Europe the Van Rysselberghe system is very extensively used over telegraph wires, and the impulses of telegraphy, which are sharp and abrupt, are so reduced by introducing condensers and self-induction coils that they assume this harmonic form, so that they become no longer capable of producing any effect on the telephone, and the telephonic impulse can be superposed over them to reproduce articulate speech.

There is one important fact in regard to systems of transformation that has not been alluded to this evening, namely, the static effects which are produced by the passage of the current in the conductors. If we consider a transformer, we see at once that it

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is composed of a conductor and a dielectric. If we consider the secondary as merely a certain amount of surface with the circuit open, we have in effect two large surfaces brought into comparatively close opposition to each other, but separated by a dielectric which is the insulating substance, remembering the fact, that the charge of a condenser is a product of the electromotive force into the static capacity; it seems quite plain that even a very small static capacity would be able to give rise to very large static charges. It is true that we reverse the impulses of the dynamo and that the reversals take place so quickly that the process of charging, which requires a certain amount of time, will not have time to take place fully. I know that at the time when the subject was first discussed in Europe, there was some apprehension regarding the static effects to be anticipated, and I have heard that in some installations, I do not know whether in this country or in Europe, it had been found in practice that static sparks could be drawn from transformers. Now, here is a state of things which certainly demands investigation, and if it should prove to be at all an evil, certainly a remedy must be provided for it. I understand that Professor Thomson himself has anticipated this problem, has probably come across it and has suggested remedies or means by which it might be remedied, and as we have all, no doubt, greatly benefited from what he has said, I think that we would be very much pleased to be enlightened further on this subject and also on some of the other topics which I have no doubt he understands fully.

PROFESSOR THOMSON:—I will say in regard to the efficiency of the wire of an induction coil that it is certainly possible to produce a higher electromotive force in a wire subject to induction than it is possible to produce in a dynamo armature. The reason however, may not be the same. It is practically a greater speed that does the work; that is, the alternations may be made at various rates; we can have 10,000 alternations per minute or we can have 15,000 or 20,000, and it would naturally result that if the field of the induction coil should be changed 20,000 times and to the same degree, that at that rate of alternation the wire should give out in the secondary (at least a certain length of wire should give out) twice the electro-motive force that it does when subjected to 10,000 and also that the primary wire should kick back, as we may term it, with a double kick, or in other words be able to hold back an electromotive force twice as great.

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The question arises: Is the secondary wire *S* (fig. 1) in the magnetic field? It is not; that is a certain fact. The magnetic field is around it and does not show any polarity whatever and the

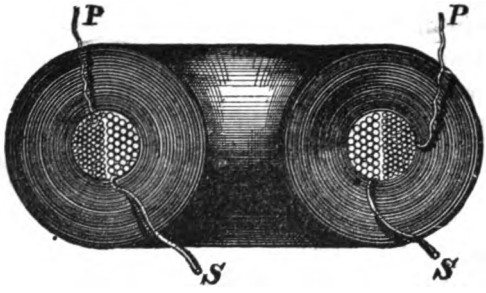

Figure 1.

secondary wire is not in the field; but the secondary wire was in the field at the moment when the magnetization was going on. Consequently the secondary wire gives out a current when the primary wire is beginning to take the current up to the maximum which it may reach. To make that plain, we will separate the wires a little. We will call each a single wire.

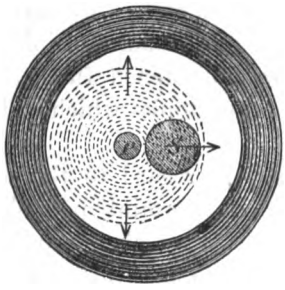

Figure 2.

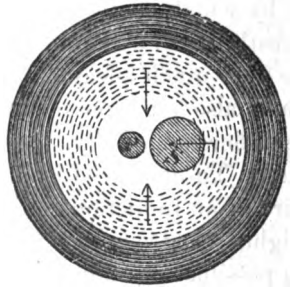

Figure 2 A.

That will be the primary *P* (fig. 2); this the secondary *S*. Now, what will be the effect if we pass a current through the wire *P*? It will cause circular magnetism around itself, and that circular magnetism will emanate in all directions quickly, and stop only when it reaches the best medium, that is, when it gets into the iron. That is my view of the action. I do not know that such view has been adopted by others at all, but I look at it in this way, that the wire conveying a current gives out as it were shells of magnetism, rapidly expanding to large dimensions. But if they meet with such a good

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atmosphere as iron, they condense themselves in the iron. What does the secondary do? If it has an open circuit it does nothing. If it has a closed circuit it develops a current. I say when it has an open circuit it does nothing. I am not strictly correct there. It develops only an electromotive force in the two ends of the secondary, which, if there is a circuit to produce a current over, will produce that current. But the very fact of the passage of the current in the secondary tends to produce just the opposite magnetization; (fig. 2 *A*) that is, as the primary lines pass across, the secondary would oppose them by producing a field of its own. But if the primary current is much the stronger, then the secondary has no chance to have a field of its own and it kicks all the harder for that reason; that is, it gives out more electromotive force or current just because it cannot have its own way.

As to the actual practice in regard to the length of wire, let us, before stating what I know to be the case in regard to such action, see what we have in the alternating current. We have an increasing current from zero up to maximum (fig. 3.)

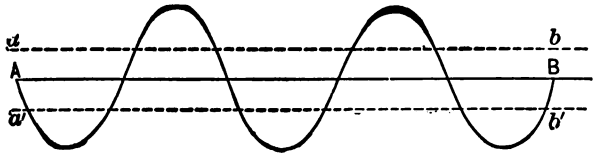

Figure 3.

And following the current down to the zero, and oppositely following it up to a similar maximum and so on through, what volts shall we say such current has? Shall it be measured by the distance between the top and bottom of the wave, or the average of positions on the wave, *a* to *a'*. Now, it is evident that in running an incandescent lamp the maximum electromotive force is not used. When you put a 75-volt lamp on such a current, you do not take that; the maximum must be higher than 75 volts, because the electromotive force does not last all the time. The maximum differences of electromotive force are probably nearer 150 volts, and we have a point near the zero line where there is not any difference. We must then take the average and that is the average volts. You see that this gives us another view of the electromotive force developed in the coil. If we count the maximum difference, then this wire is developing more than it appears to develop per foot or per number of feet. Now, in actual ex-

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periments with alternations of very nearly 10,000, the volts generated in such a coil per foot will be away down. I should correct that expression, the number of inches to develop a volt by such an arrangement will be somewhere between six and twelve in the primary and secondary. But the singular part of it is, suppose we take as a figure nine inches, with rather slow alternations—I take rather slow alternations—but nine inches develops a volt in either primary or secondary coil. What does that mean? Why, it means that four and a half inches nearly develops a volt of maximum difference; that is taking the E. M. F. from a point at the highest point in the wave to the opposite highest point, it is a good deal higher than the average. I cannot say just now that the relation would be exactly one or two; because that would depend upon the shape of the wave. For instance, this wave might have such a form: (Figure 4.)

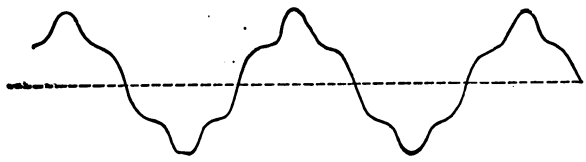

Figure 4.

Taking an extreme case it might be something of this kind: (Figure 5.)

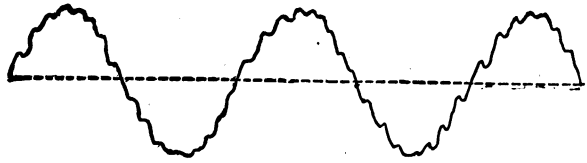

Figure 5.

And it might be an irregular wave and the average of the electromotive force in that case would be lower than in the regular wave. The point in regard to induction in telephones is also made clear by studying a moment the action which occurs in fig. 3. From any point to another lies a certain change in the phase and so all along. The changes are quite gradual, and if the diaphragm of the receiving instrument gets an induction which is so gradual that its motion is something like a slow impulse; it will not give a blow on the air hard enough to be heard distinctly; but if that

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wave should be of the character of this (fig. 5), then every one of these little jumps will cause the diaphragm to hit the air a blow which would be heard at the drum of the ear.

In relation to the static charge, I do not attach so much importance to it as would at first seem to be attachable to it, for the reason that the actual amount of condensing surface in the induction coil is not a very great amount after all. It is quite possible to take rapidly alternating discharges from a little magneto electric machine which may represent far more current energy than the charge or discharge of a moderate sized induction coil; although it is possible that with induction coils working hundreds of lights there might be a stinging shock obtained by touching the wire of the induction coil. The static charge, however, does certainly exist, but it represents very little current so that a person may take it without any trouble. A person standing on an insulated stool can have 10 inch sparks drawn from him and he does not mind it at all. He can charge his body through the potential of many thousands of volts and he can discharge that potential from his knuckles without any other feeling than a little shock in the arm. I have taken by accident discharges from Leyden jars—say three gallon jars at an inch and a half of striking distance—and all that I felt was a violent shock which was over in a moment. It may benumb you a little but it does not amount to anything. As to another source of danger in the use of induction coils; such an accident as this may happen at any time—by moisture or by faulty construction or some other such cause—the primary may become connected with the secondary or be so close to it as to cause a leak from one to the other. No particular danger should result from that alone although there would be a more vigorous discharge, statical in character, from such a connected secondary, because on the one side of the leak you would have a rather long line and at this one point you would be able to get the discharge of your whole line in rapid succession; but the chief danger in such a case is the formation of a second contact to ground. The induction coil which at the same time had a contact to the primary line would necessarily take the potential of that line, and we will suppose the ground on the other side of the line. Now, a person may go to the lamp under those conditions and his fixture might be near a metal object, it might be connected by moisture; he might stand on the moist floor and the result would be the current would come down through his body and he would be subjected to the

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full potential; and there is no doubt that if he should be foolish enough to stay there he would have to stay there until somebody took him away. But a man when he is shocked generally drops away from the thing that shocks him, but he may be, as we term it, "hung up"; that is, he cannot let go, and that is undoubtedly the reason why accidents happen in arc light distribution. If a man can get away at once even such a potential as 2,000 or 3,000 volts will not kill him; as we have had plenty of experience to prove.

To avoid such dangers in alternating current lines we provide a very simple means. We take our secondary here and ground it. If the insulation between the primary and secondary is as good as it ought to be at all times, the grounding of the secondary will not hurt anything; that is certain. What then occurs? If the man takes hold of the secondary wire and touches a radiator connected with the ground or a water pipe, he is already shunted by a good conductor and he cannot get anything to hurt him. Put this wire to your steam radiator or water pipe. That addition to the system would save us from all shocks: but it would introduce another element of irregularity and danger; that is, it would provoke contacts to the secondary line; but nevertheless if a contact does occur cut your line off altogether by putting a fusible plug in the circuit leading to the primary, so that if there is any diversion of current through to the secondary and to ground, the plug will blow out. There is another danger of course in having this ground connection and that is the danger of atmospheric discharges —lightning, etc. That, however, can be avoided by making the insulation here heavy, and in fact separating the wires by an air space and then putting near the primary line where it enters the building, or in any convenient points an ordinary lightning arrester in which the spaces between the line and the conductor to ground are so small that an atmospheric discharge will seek the ground through that and not through this. Of course it would be necessary in running such a system to test it for grounds just as lines are tested to-day. [Applause.]

Mr. Church :—My proper office here would naturally be to defend the secondary system, otherwise the converter system, against attack; but I find that there has been no serious objection raised. In fact there seems to be a unanimity of sentiment in favor of it, insomuch that it seems to me if we were placed in series we might generate 4,000 or 5,000 volts electromotive force in the way of commendation of the system.

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With reference to the opinion of Doctor Siemens, I have only to say that I should reply to his criticisms by subscribing my fair share toward paying his passage to this country to see the thing done. [Laughter.] I was recently at Daly's Theatre and witnessed that charming production of Shakespeare's "Taming of the Shrew" and I noticed that *Petruchio* insisted that he saw the sun, in defiance of the fact that the moon was shining; and it strikes me as ridiculous (if I may be allowed to couple that term with so distinguished a man as Dr. Siemens), to state that the secondary converters will not govern within better than a range of four per cent. in defiance of the fact that the company with which I am associated is operating these converters commercially and deriving its pay from the plants. The whole thing is reduced to an ordinary matter of fact. The variation is not appreciable by any of the instruments that we can bring to bear upon it outside of the laboratory. We are putting in 100 volts and taking out better than 98 and selling them to people and getting our pay for them. I contend that the final touchstone in the eye of the practical man; and more important in the eye of the man to whom we sell is, "Can I take this system, disregarding the *whyness* and simply secure the result and put it in my vest pocket."

The question has also been raised as to whether the distribution upon this high potential system, coupled with underground circuits, might not be essentially as bad as on the ordinary multiple system, eating itself up in capital before going out to any considerable distance. Let us look at it from the commercial standpoint. Copper is not the sole element of economy by any means. In fact I think there has been an injustice done to the secondary system by insisting that its prime usefulness lay in the reduction of the first cost of street wiring. That is one way to put it, but I think it the least forcible way. As I judge from daily contact with it commercially, the usefulness of this system is largely in extending your business from a central station to the remotest point. You have certain fixed expenses—I am now talking to you from the standpoint of the man with whom I deal—these expenses consist of salary accounts, investments in buildings and real estate, and interest and depreciation, and what not. Now, you wish to dilute that expense as far as possible and to make it bring you in a large amount of business. Therefore, if it were true,—which permit me to state it is not by a large majority,—that the increase of the cost of copper was in any such ratio as has been alluded to by Dr.

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Siemens, it still would leave untouched the fact of rendering the other fixed expenses of the intsallation available for the increase of business. That fact has been commercially proved with us beyond peradventure.

The use of the converter or high potential system, permits the running of wires on a very small percentage of drop. With the ordinary multiple arc system and low potential, your copper is so large at best that you have got to submit to ten or fifteen per cent of drop to secure a reasonable amount of copper at all. The converter system on the contrary enables you to run with a two per cent. loss in the primary mains and bear in mind that that saving is a merchantable article. Instead of sacrificing a certain amount of the energy of your plant in your lines, you take it out and sell it to a customer and put the dollar in your vest pocket. Furthermore the low drop has an enormous effect upon the life of the lamps, which is again a commercial question. Furthermore the secondary system enables you to maintain an almost absolutely uniform potential throughout your distribution.

Thus I might drift along, touching upon a host of points which are in no sense scientific and yet seem to me to carry much weight, if we consider the question in its practical and every day aspect. I am pleased to say that so far as our work has progressed—and we are treating it entirely on a commercial basis—no serious difficulty has arisen that we have been obliged to overcome.

Professor Thomson has alluded to one other feature of the system. He states that one of the characteristics of a certain form of broken current is that it discourages your moral nature entirely, by the intermittent and very sudden and unexpected changes it takes on. On the contrary, he goes on to say, the peculiarly rhythmic and wavy motion of the alternating current is a tranquilizer, and the alternating machine may therefore be said to be a moral agent. I have noticed the effects upon my own moral nature since I have been in the business and I confess I was unable to account for it until this moment. [Applause.]

Mr. Ralph W. Pope:—One of the objects of the Institute, I presume, is to do justice to all systems; and, as that particular system which is affording us radiance this evening has furnished a text for two or three of the speakers, on account of its winking and blinking, I might say in explanation that this plant is operated by a dynamo in the building. But that is not the point I wished to bring to your notice. This scene of revelry has now

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continued to such a late hour that, on account of the departure of the engineer, the dynamo is not equal to the emergency, consequently, earlier in the evening, the lighting was switched from the local plant to the central station system, and this switching operation caused the blinking which we saw.

DR. MOSES:—I stand corrected. The remarks of Mr. Wetzler with regard to Mr. Siemens's criticism, recalls to my mind something that occurred in which Mr. Siemens figured. For some reason or other Mr. Siemens did not like Mr. Edison—until their interests finally became the same in Germany. I heard Mr. Edison's agent (who was present at an interview with Mr. Siemens when the business was settled) say that Mr. Siemens had remarked: "Well, I never did think that I could be made to reconcile with him, but you see what a man's interest will do." May we not on some future occasion listen to a similar conciliatory remark from Mr. Siemens about secondary distribution? Mr. Church cites a case from the "Taming of the Shrew," which is very apposite and recalls to my mind another anecdote. Once a very stubborn sort of man got into difficulty. He owed money to a person who had him arrested for debt. So he said to the bailiff: "Look here—this is an absolute impossibility. You cannot arrest me. My lawyer says you can't." "Very good, I will arrest you and take the risk." So the man was arrested and he wrote to his lawyer saying: "How is this? You told that me I could not be arrested for debt." "The fact is," said the lawyer in reply, "You can *not* be arrested for debt." The prisoner writes back: "The fact is I *am* arrested for debt." Now, Mr. Siemens may talk about four per cent. fall of potential rendering incandescent lighting impossible by secondary generation, saying that the bringing down of its potential from 104 to 100 volts would be so noticeable a thing that people would not use that lamp and so on. But the facts are, as I have seen them in South Pittsburgh, people were using the lamp. The lamps were prisoners; they were there, all that Mr. Siemens may say to the contrary notwithstanding.

There were one or two points Professor Thomson referred to that are very interesting, which I will advert to, parenthetically. He says (making a sketch) if there were waves of small amplitude intercolated in these alternately rising and falling variations, there would be produced a kind of kick upon the ear that would be audible in a telephone He will recall perhaps a remark that Professor Tyndall made, when on one of his excursions in the Alps

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with a companion and hearing an exceedingly shrill and ear piercing noise, said: "What is that deafening sound I hear?" The man said, "I do not hear anything at all." Professor Tyndall looked at his companion, in amazement. "You do not hear that sound?" he said. "No" said the man, "I hear nothing." Well, it was a question of fact; and Tyndall tried to explain it—and did explain it very reasonably—by saying that his ear was tuned a little higher than the ear of his companion and that the grasshoppers which had collected in great swarms in his neighborhood and were producing this fearful noise, emitted a note of so high a pitch that his ear could hear it, but his companion's could not.

Now, if you calculate the variations there are in an ordinary alternating circuit, they will amount to about 250 a second. Two hundred and fifty variations a second would make a very pleasant musical tone; but these minor waves would be so small compared to the whole amplitude of the main waves that they would be altogether inappreciable to the finest tuned ear. So I doubt whether these supposed rises and falls on the larger waves would produce an unpleasant sensation.

There is another point that I would like to call attention to. Mr. Church referred to running wires overhead. I think that very serious consideration ought to be given to that point. While the underground commission is still undecided in its action, the electric light companies should determine whether it is absolutely necessary for wires carrying alternating currents or currents of very high potential to go underground. I think there ought to be a distinction made. Although an alternating current may not injure a telephone, still it is not every current that is perfectly uniform or harmless. There may be changes in it that might introduce some disturbance, and such things should be avoided. For that reason, it would be well for the whole electric lighting interest to unite in calling attention to the fact that it would be better to leave the air to the distribution of high potential currents for lighting, and to take the earth for telegraphic and telephonic distribution and the distribution of power. There ought to be a dividing line between the two classes of currents.

Professor Thomson made a very interesting allusion to the interaction of the waves of electricity sent off from both primary and secondary coils, which induces me to pay a tribute to the one who made, I think, the first observation of that action, by recalling to mind that article of Faraday's in the Philosophical Maga-

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zine (1831), in which he announced the discovery of voltaic induction, when recording that a current brought over a parallel closed circuit will induce a current in a neighboring wire. He then gives a fundamental experiment. But he makes one leap there which must be filled out by the imagination of the reader. It is a marvel to me that a man would accomplish so much and pass it by in perfect silence; but the experiment itself proves that the very pretty deduction that Professor Thomson made must have passed through the mind of Faraday at that time.

Faraday passed his current through the primary and he took off a current on the secondary neighboring wire by joining its ends—making a closed circuit. The first experiment that he records was this:

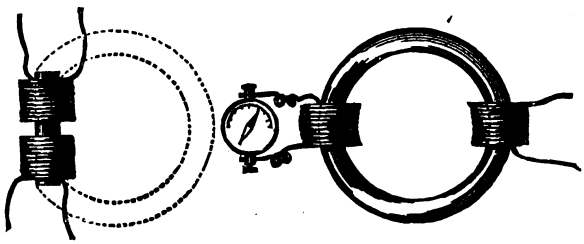

Figure 6.

He noticed that the lines of force emanating from that iron core—external lines—passing here were weakened by the poor conductivity of the air and reasoning out that the lines that were cut by the entrance of this current into the primary coil from an infinite distance, cut the magnetic lines that were induced through the iron across into this coil, he closes up at once his circuit, makes an iron atmosphere for it and he gets a closed ring form. Thus the first experiment that he records shows that he thoroughly understood that the rushing up of the current from an infinite distance produced lines of force that were cut in the opposite direction through the ring of iron by lines generated in the secondary which as Professor Thomson acutely stated, were really a part of the primary.

MR. RIES:—It has been stated by Professor Thomson that the alternating current that he used, on account of its undulating character had no detrimental effect upon the telephone wires running parallel with it. I should like Professor Thomson to inform

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us what the potential or electromotive force of this alternating current was. It has also been stated that this undulating movement was a gradual one in contradistinction to the jerking movement caused by the intermittent current. Now, it is known that the diaphragm of a telephone will vibrate a certain number of times per second, according to the number of alternations in the primary. The stronger the positive and negative impulses on the primary circuit, the stronger it would seem will be the magnetic attraction, and consequently the amplitude of vibration of the diaphragms on the telephone line; so that taking that further modification of Doctor Moses, in which the undulations due to induction were described as being in the nature of a very rapid wave motion, having an independent action that would have no effect upon the diaphragm. Now, if these high tension induced undulations had no effect, would not the slight inductive effect of the telephone current itself be still less effective in causing the diaphragm to respond to them, and would the additional telephone currents be of sufficient strength to prevail over the stronger induced currents present on the line, even though the latter be of a humming or musical character? Another thing—it has been stated by Mr. Pope, in referring to those English experiments, that the *rectangular* line caused disturbing effects upon neighboring telephone wires, etc., whereas when the line is put into the form of a parallel metallic circuit the incoming currents neutralize the outgoing currents to such an extent that their effect upon the neighboring telephone and telegraph lines was not noticed practically. If that is the case, is it to be assumed that on a metallic circuit the interruptions—the alternating impulses will oppose each other and thus reduce their mutual efficiency, or are they only active with respect to the surrounding telephone and telegraph wire.

MR. FRANK L. POPE:—Before asking Professor Thomson to reply to Mr. Ries, perhaps I had best show by diagram the arrangement of the wires in London. (See figure 7 on next page.)

The original arrangement was something like this. Suppose *a* to be the station. The telephone lines crossed the loop in all directions. The wires were in all cases put on the tops of buildings—although we are told that "they do not have any overhead system in London." Yet this lighting system is all overhead. The diagram now shows the arrangement that is in use which prevents interference with the telephone. The Westinghouse Com-

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pany used a line at Pittsburgh some two miles long or more, which went on the same poles as the telephone lines, but did not prevent conversation from being carried on through the latter.

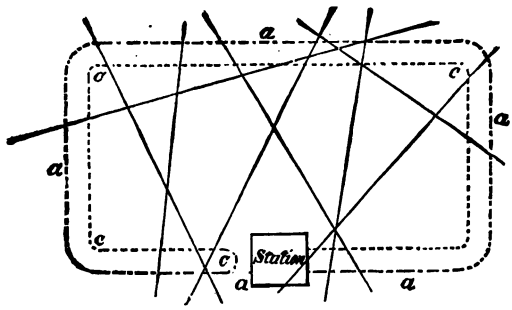

Figure 7.

MR. CHURCH:—I am under the impression that we reached a satisfactory result in that case by simply crossing our lines at intervals of every few poles. I was not present at any of the experiments, but that is what I think I have heard.

MR. WRIGHT:—Yes, there was a slight trouble due to that, but it was overcome by crossing the lines, I think, about four or five times. At Plainfield I have no trouble. I cross my lines at every third pole. I started at Plainfield to put in the old system of direct current and Mr. Westinghouse came one day and told me to remove my machines and install the alternating system. I knew nothing of that system at the time. We put up a 650 light machine, and we have now wired the business portion of the town. We have running at present some 450 lights. I went down to Pittsburgh and was there for a couple of days and saw a thousand lights running three miles from the factory. I returned after spending a couple of evenings there, and two months later I had my station in order. I started there with green men. When I was ready, I signalled to the engineer to start, watched my volt-meter and went out to look at my lights. They were all running well and since that time we have had no trouble whatever with our machines or circuits. We started on the 1st of February. With regard to the variation in potential due to the different loads on the converter I had a little experience. In Plainfield, all my converters are connected in the primary circuits and having there a few converters at first, I connected all my converters on the

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secondary circuit and took my services into my stores from the secondary wires. In one case I had one converter working independently and I had wired on that 53 lights in one store and 16 in the other. This was on a side street and I had no means of connecting it up with the other set of secondaries. The 53 lights were not all intended to be in use at the same time, but when we started the people at the store naturally played with the thing a great deal. I happened to be in the store at one time and I noticed a little change in the light when a large number of lights were turned off. I could see a change and I drew the attention of others to it, but they did not perceive it. It was not perceptible to the uninitiated; I was looking for it and saw it. I had a fifty-light converter and was sometimes running sixty lights on it for a few moments. We had the whole of this store lighted continuously. I cannot say anything about the measurements, because I have no means of making measurements down there; moreover it is not in my province, as I am dealing with things in a practical and commercial way. As far as regulation is concerned, we have no regulation in our station to speak of. When a large load is taken off, we vary the current from our exciter slightly, but there never is so much load taken off at one time as to affect that very materially. We take readings about every fifteen minutes; that seems to be about as often as is necessary. We have had no trouble with the armatures. One armature went in the first day and is there yet. It has been running now since the 1st of February on an average of fifteen hours a day, and I have no spare armature. I do not know how many lights I have running now. When I returned last night there were some four or five stores added to the circuit. Plainfield has been without a license law for some time and my income was to be derived very largely from the saloons. We put on five saloons last night, during the heaviest part of my load about half-past eight; so that my load somewhat increased last night. (Laughter.)

MR. WHEELER:—I am not sure that I understand what Dr. Siemens's objection is, but from what Mr. Wetzler says—that the system would not regulate within four per cent. I imagine that he means that when the load of lamps is increased the increase of current would cause a greater loss of potential in the coil. If that is the only difficulty, I do not see why that cannot be overcome. The converter coils seem to work very well indeed and I do not see why they cannot be handled in just the same way as a dynamo

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is handled. If they won't regulate, why cannot they be made to regulate? For instance, if the loss is due to increasing the number of lamps why can't the coil be so arranged that as more lamps are turned on, more coil is turned on, or why could not a differential wiring be used?

MR. CHURCH:—In reading the reports of the convention at Philadelphia I noticed some statements to the effect that we had been burning out armatures rapidly—I think something like twenty a month was named. My partner, Mr. Kerr, replied very properly that it made no difference whether that was so or not—that it was an incident of construction. But the fact is that out of the entire complement of stations we have running, we burnt our first armature last week. We do not exactly know what it was due to at this moment. But the meter was reading some 65 amperes on a machine calculated to run but 45 amperes and there was a short circuit somewhere that was taking an immense amount of current. The armature of course gradually heated up and burned out, and the people on the circuit knew nothing about it. That was the first burned out armature, outside of our own experimental work in the shop. We have ripped out two armatures by simple mechanical contact. The binding wires got against the pole pieces and simply stripped off from the armature without the slightest burning—purely a mechanical action. A statement was also made that we were suffering enormously from the short life of the converters. The simple truth is that we burnt our first converter about ten days or two weeks ago.

MR. MARTIN:—I would like to ask Mr. Wright in regard to the distribution of these converters. My friend Duncan, in Pittsburgh, is very well pleased with a secondary generator plant there and stated at the electric light convention that he had one of his converters on the poles but that in one or two cases he did not think it necessary to have them attached to the building.

MR. WRIGHT:—At present my converters are on the poles. My lighting is scattered and I have not a large number of converters, but I have more than sufficient in total light capacity. They are sometimes about four or five poles apart, (the distance between poles averaging 120 feet,) a great deal depending upon the disposition of the lighting. Of course I may have occasion in some cases to place my converters in the interiors of buildings but generally outside the buildings. I propose in Plainfield, in the residential portion of the town, to run my branches from the sub-mains

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into the central portions of the blocks to distribute from that point.

I forgot to mention that I am running in my station at 104 volts. My line is calculated, in the business portion of the town, for 1500 lights. Of course the business portion of Plainfield is not very large and my loss was intended to be 1 per cent. on the primaries, but I happened to have some old arc wire that I wished to make use of, which increased my loss about one quarter per cent., so that practically just now I am not getting my loss in my primaries on account of having 400 lights where I am wired for 1500. I have got about 1 per cent. of loss on my secondaries. My lights are well up to candle power with 104 volts in the station. In fact people tell me my lights are over candle power. As I say, my voltage is 104 in the station. At present I am simply regulating by station lights where the loss is practically *nil.*

MR. RIES:—Are the primary coils of the transformers connected in parallel?

MR. WRIGHT:—In parallel.

MR. RIES:—And you find the regulation for that reason better; that is to say, any variation in the circuit of one transformer will not affect the secondary circuit in the other; the parallel connection tends to facilitate the vertical regulation.

MR. WRIGHT:—Certainly. Although it is not generally intended to connect the secondaries, I should do so in the business portion of the town. I shall insert other converters as my light increases.

MR. MAILLOUX:—I would like to have somebody tell me whether anything has been done to develop the application of the secondary transformers for distributing power by motors. Dr. Moses has told us that he could send one impulse to, and the other fro in the same circuit. It would be interesting to know whether this to-and-fro matter is only theoretical, or whether it is practical and has been accomplished. I would also inquire whether in the event of a system of distribution by periodic impulses of one polarity on each circuit, the size of the transformer and to a certain extent the method of its application would not need to be changed to conform to the different manner in which the energy would be distributed, because we shall have now energy being supplied by the circuit for only half the time, and of the energy so supplied we must store enough in the induction coil to maintain the supply during the other half. In other words it must produce a certain magnetic reaction which will be sufficient to keep up the energy during the remaining half.

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A MEMBER:—Wasn't it generally considered settled at the last convention of the Electric Light Association, by Mr. Sprague, that the economical transmission of power by electricity could not be arranged on an incandescent light circuit, and it was necessary to have a separate plant for that purpose?

MR. MAILLOUX:—As I understand it, the means by which we distribute energy by use of transformers are so different, and each transformer is to a certain extent so completely isolated in regard to its action from the rest, that if we find a solution, adapted to the transformers in general, I do not see any reason why this solution would not admit of the common use of motors and lights on the same circuit with equal efficiency. It is therefore for that reason I bring up the question; that is a point on which I have no doubt we are all in the dark and about which we would all like some information, and as a practical man, I would like to ask that question.

I would also like to know what has been found in practice to be the difference in efficiency between the coils of the ordinary straight description and that of the circular form, which is generally used in installations for distributing energy by means of transformers. I have had this question submitted to me lately on several occasions, and I was of the opinion that the difference in efficiency would not exceed two or three per cent? I would like to know whether any such data has been obtained from practice.

MR. FRANK L. POPE:—I think the question which Mr. Mailloux refers to was pretty thoroughly investigated by Professor Ferraris. The result was something like this—that there was no very great difference in the co-efficient of transformation, but there was a much smaller amount of iron and copper required to do the work with the closed core than with the open one.

MR. MANSFIELD:—The subject of the distribution of electricity for lighting purposes has been pretty well handled by those interested in converters; but I fail to see exactly of what use the converter is commercially. In the installation at Plainfield, we have not such a great distance to annihilate; and all men who are engaged in the transmission of power, and I am one, talk about annihilating space. Mr. Wright, I think, spoke of using the converter right in his own station. Now I do not see that there would be any economy there over the direct system, unless when you go to a distance you want your alternating currents or your

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high potentials there so as to annihilate this distance. You put in your converters or transformers so as to get the electromotive force down to a safe working basis; but with motors I presume that the same converters can be used. But I do not see just how the economy comes in, in using the converters so near the station. When I first started in the electrical field, which was only a short time ago, I heard Dr. Moses speak in the most glowing terms of placing some sort of an electrical machine in the bottom of a coal mine, in the wilds of Pennsylvania, and transmitting the energy to New York and utilizing it for our lights. I thought that was a grand scheme. But of late I have had to figure somewhat on transmitting energy to a distance, and I met in connection with that recently an exceedingly practical man. He asked me if I could transmit to any distance any amount of energy. I said yes. He wanted to know how far. I told him any distance he wanted, and he specified twenty-five miles, and he went a little higher, and I thought I would keep on as high as he did. Finally he got to a certain point where he smiled to himself, and asked me if I was aware of another method of transmitting energy, so to speak, but energy which was tied up. Well, I did not see just what he meant and I said no. He then spoke of the great railroad system which we have now, and that set me thinking, and I went home and commenced to figure, and from the census reports I learned that the cost for transporting a ton of freight on some seventy-nine of the greatest railroads in the country, if it was figured down on the basis of per ton mile, was only about seven mills. Well, you can easily figure from that basis that a railroad will be a formidable rival, if you went up into twenty-five or fifty miles even. They could transfer the coal from one place to another, burn the coal in their furnaces and produce their energy through furnaces and through steam much more cheaply than we could transmit that amount of energy electrically.

MR. MAILLOUX:—How about water power? If there is a natural source of energy, how are you going to get that to a distant town?

MR. MANSFIELD;—The natural sources of energy in this country are to a certain extent mythical. If you will consult the census reports you will see that there is not so much water lying around loose as some people think, and that the Lowell mills and the Lawrence mills and the Paterson mills and the mills at Holyoke, and so on, all have steam engines. In my opinion a station estab-

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lished with the ordinary arc light potential in the middle of New York city exactly in the center of the longitudinal axes of the island would quite easily handle the motor problem in the entire city and at even a less potential than they are using on some of the arc light circuits. The existence of danger is another question. But I think that can be simply answered by the fewness of the lives lost on the arc lighting circuits. So that after all, perhaps right on the arc light circuits we motor men have a means for carrying on our business without interpolating converters.

MR. WRIGHT:—The last speaker made a remark regarding a converter in the station. I can hardly light my station without a converter, seeing that I have a thousand volt machine and my lamps are 100 volt lamps. My lines in Plainfield at present average about five thousand feet from the station and I am laying out one line which will be four miles from the station.

PROFESSOR THOMSON:—In regard to the economy of wiring, I think that you may say that taking high potentials and distributing in multiple arc, there is a good point just there; when we use an arc light circuit we have to take the whole current all around the circuit; that is, the wire must be large enough to carry with a small loss the whole current which may be five miles away. When we take a multiple arc circuit at high potential the energy is given out here and there; we do not carry it any further; but the amount of copper needed will be very much less to carry the same energy than on an arc light circuit. Take it at the equivalent electro-motive force, and assume that your work is done over a district pretty evenly, and you are practically delivering say an energy equal to ten-horse power at a block or two away and that energy has not to be added to the current which is traversing the whole line; it is dropped right there. Now the energy which goes further is carried by the current, and so it goes; so that there is really an actual saving of wire and a considerable saving over the wire used on an arc light circuit.

In regard to induction, I may say that the system which is figured on the diagram has a double wire going out and returning which is almost a necessity in the running of our plant. Almost all arc light circuits go and return on the same poles and the nearer the outgoing and returning wires are placed the better it will be. But as we cannot place them close together, we can do the next best thing; we can interchange their positions—cross and recross back. All that we have to do is to produce such a condi-

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tion in the wiring as will not give an effective magnetic field which can act on the other wires, or if we do get magnetic fields which will get on the other field, we must use opposing ones. In arc lighting it has been found that all that is necessary to do is to run the wires parallel and very little effect is then produced on any neighboring wires.

With the alternating current machine, you can turn up and down a lamp without the loss of energy amounting to anything. Now that seems a surprising fact, but it is true. The lamp may be run just as you would a gas burner; turn it down so that the filament is red, by a little attachment no bigger than my fist. It is simply the interposition of a very little coil—not an induction coil—sheathed in iron and the capability of putting more or less wire into the circuit; in other words introducing a good converter of electromotive force into the circuit, which will prevent the current going through the lamp, and which will do that, not as a resistance in the lamp, but by throwing the electromotive force back on itself. That can be done to a single lamp or it can be done to a group of lamps.

On the continuous current circuit there has been and is a continual strain after high volt lamps. It is regarded almost as impracticable to run any distance unless you take one hundred or one hundred and ten volt lamps, the highest that can be commercially made. The reason is that when you get beyond that, the filament will almost sag by its own weight, and the one hundred volt lamps that are made to-day are generally of a low efficiency, compared to lamps of lower volts which will give exactly the same life. A fifty volt lamp, for example, can be made to use less energy than a one hundred volt lamp, and give the same light.

MR. WRIGHT:—About three watts as compared to four or even less.

PROFESSOR THOMSON:—But when you get much below three watts you sacrifice life considerably.

In regard to the regulation, a station operating on a continuous current system over any distance has a drop which will amount to probably ten, fifteen and sometimes even twenty per cent., and that is the case especially where the object is to save wire, and where the fuel is pretty cheap, and where they can afford to run heavy losses on account of fuel being cheap. On the alternating current system the drop can be made certainly very much less on the drop line. The drop in the induction coil itself is altogether

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within our control; at least so it appears to me. The high work which is obtained from the wiring makes the resistance of the wire bear such a small proportion to the actual electromotive force at work and to the resistance of the circuit on which it operates that there is a practical regulation. The local line, of course, can be wired so as to give very little drop without involving the use of a great deal of copper.

As to the motor question I think that the alternating current motors can be made to run nearly as efficiently as continuous current motors, and with the saving of drop in the mains we can afford to run them less efficiently. It is not absolutely necessary to change the high potential current by an induction coil for the motor. If the motor is built to stand the potential in the main circuit, there is no need of reducing the potential.

MR. CHURCH:—Except as a matter of personal safety.

PROFESSOR THOMSON:—That is all. But it seems to me that as the alternating current motor is an apparatus that has not got a commutator, necessarily the machine may be boxed up and run with fair safety. The only difficulty about running motors is getting them started. The fact is, that if the impulse comes at a certain rate, unless the motor takes that impulse at the same rate, it will not start; that is you must give it the speed first; you must put it in tune with the rest of the circuit by giving it the speed; than clap on the current and it will run at that speed absolutely. If you overload it, you will draw it down and it will stop. Now, I have in my possession a little machine which, put on an alternating current circuit, will start from the state of rest and run right up to speed, developing considerable power. That machine may not be as efficient as the alternating current motor is, but I can put that little motor on the same shaft with the larger motor and give it the speed of that little motor, having the whole thing under my control. (Applause.) I take off the load from the motor and I put this little motor in circuit, and I put the larger motor up to speed in that way and then throw the current on to it and throw off the smaller. I am not at liberty to describe in full that arrangement. As yet it is not fully developed, but I hope before long to have it in such shape that it can be fully discussed.

Adjourned.

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General Meeting.

May 18, 1887.

The meeting was called to order in the rooms of the American Society of Civil Engineers, 127 East 23d Street, New York city, at 10.45 A.M., by the retiring President of the Institute, Mr. Frank L. Pope.

Mr. Pope addressed the meeting as follows:

Members of the Institute and Gentlemen:

In bidding you welcome to the fourth annual meeting of the Institute of Electrical Engineers, it affords me much gratification to see such a large and representative attendance, and to note the evidently increasing interest manifested by the electricians of the country in the welfare and prosperity of our organization.

The year which has elapsed since our last annual meeting has proved one of unusual prosperity in all branches of legitimate business having to do with the manifold industrial applications of electricity. Without exception, so far as I am aware, the manufacturers of electrical machinery, apparatus and supplies are all fully employed; some of them are working overtime, and many of them have in contemplation or actually in progress extensive additions to their facilities.

While rapid development, enlargement and extension seems to be at present the rule in every department of the science and art which we, as an organization, especially represent, it may not be amiss to refer to the exceptional progress which has been made in certain specific directions since our last meeting. Among these may be mentioned the transmission and distribution of mechanical energy through the agency of electric motors, and especially the application of these to minor branches of manufacturing in large industrial centres, and to the propulsion of street railroad cars; the largely extended employment of accumulators or storage batteries for the lighting of buildings and railway passenger cars; and the introduction of long distance incandescent electric lighting, which has at length apparently been made both practicable and profitable by the employment of alternating currents and induction

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apparatus. Last, but not least, should be mentioned the new art of welding metals by the aid of the electric current, which seems likely to occupy a vast and immediate field of usefulness, and to create numberless new industries, to say nothing of revolutionizing some of the existing ones which have come down to us almost unchanged from the days of Vulcan and of Tubal Cain.

I am sure that it will be a source of gratification to you all to learn that the prosperity of the Institute of Electrical Engineers has kept fairly abreast with that of its members and co-workers in their individual and professional capacities.

The series of special meetings, each preceded by a dinner, which have been held in this city, during a portion of the past year, have proved to be most successful and enjoyable reunions, and have certainly done much to strengthen the Institute, by increasing the interest of non-resident members as well as of those residing in the more immediate vicinity of New York.

Several exceedingly interesting discussions, which have taken place at these meetings, have been reported in the professional journals on both sides of the Atlantic, and thus the information brought out has been made available to the profession generally. It is proposed to continue this commendable innovation during the coming year, and I have no doubt but it will henceforth become a permanent feature of our proceedings.

The courtesy and liberality of our much-esteemed sister society, the American Society of Civil Engineers, has enabled us to enjoy for another year the hospitality of the convenient and comfortable rooms in which we are now assembled.

While I feel sure that every member of the Institute appreciates to the fullest extent the value of the assistance which has thus been rendered to us as a society in the days of our youth and feebleness, yet in the judgment of some of our most esteemed members the time has arrived when we may feel justified in making a determined effort to secure adequate, commodious and convenient headquarters of our own. Within a day or two past, a movement has been set on foot to raise the necessary funds to carry out this project in a fitting manner, and I am more than gratified to say, with excellent prospects of success. The undertaking will be presented to-day in a definite form for the consideration of the members, and I feel certain that each and all of you will individually do everything in your power to insure its early and complete success. It is hardly necessary to say, that the establishment of the Insti-

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tute in a building of its own, equipped with a library, reading-room, and perhaps ultimately with an experimental laboratory, will give us a standing second to that of no other institute in the world, devoted to a special branch of art or science; it will directly benefit every industrial enterprise in the country having to do with electricity; it will increase the confidence of capitalists in the importance, remunerativeness, and stability of electrical enterprises, and will in every possible way be of the utmost advantage not only to our own members, but to all who are in any way connected with electrical enterprises. I trust therefore that my successor in the honorable position of President of this Institute may be enabled to signalize his administration by the completion of this most desirable undertaking.

In conclusion I desire to tender my acknowledgements to the officers of the Institute and the members generally for their kind and hearty co-operation in carrying on the affairs of the organization during the past year.

MR. POPE:—Gentlemen, it gives me great pleasure now to introduce to you the newly-elected President for the coming year, Mr. T. C. Martin, whom you all well know.

PRESIDENT MARTIN then read the following address:

Fellow Members of the Institute:

Your action last night, placing me next in succession as President to so distinguished an electrician as Mr. Frank L. Pope, and so soon after Dr. Norvin Green has occupied this chair, is one that only the results can justfy. Although my connection with the Institute dates back to its foundation, and although in the three years of its existence I have been afforded the opportunity of participating in its management, I cannot venture to regard your decision as entirely personal. I would interpret it rather as a generous recognition of the fact that the Institute has still the larger part of its initial work to do, and that work must be carried out chiefly by the younger element, which constitutes an ever-increasing part of the membership. For this great honor, and for this sign of your confidence, my thanks must, therefore, find their best expression in what the Institute achieves during the current year.

We stand to-day at an important stage in electrical investigation and development, and yet it is not given us to see or to say what will be its position in the long vista or perspective stretch-

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ing through the second half of the present century. As Dr. Priestley reflected one hundred years ago: "It may be said that there is a *ne plus ultra* in everything, and therefore in electricity. It is true, but what reason is there to think we have arrived at it?" Priestley was of those who were permitted to gaze afar off at untrodden fields of discovery, but who did not enter in. To-day the evidence of what has been achieved tells us that the greater lies before. The time is one, in fact, when science, and such a department of it as ours, offers to the more adventurous and inquiring spirits the rewards that were once mainly to be found in geographical discovery and in the prosecution of trade, but which are wanting now when even the interior of Africa has been traversed, and when commerce is carried on at apparently a diminishing rate of profit to capital. The electrician has gained, meanwhile, a foothold on the Atlantic seaboard of his new continent, and, subduing a wilderness of theory, speculation and doubt, has already won some of the noblest provinces that ever rewarded the industry and the genius of man. But beyond him lie the ranges of distant mountains, and westward of their peaks is the territory out of which he has yet to carve a score of states unnamed. Toward that great west of his science, the electrician advances, and even now he has the first fruits of exploration. But while there is this onward movement for the pre-emption and occupancy of virgin soil, we see going on an equal development in the realms already won, invention being heaped on invention, and improvement added to improvement. Speaking as one who had witnessed this change, Dr. Werner Siemens said recently: "We still remember the time when we listened with incredulous wonder to the strange fairy tale that the mysterious new force, electricity, could transmit messages with lightning speed across whole continents and the oceans which divide them; and that this same agent could precipitate metals in a solid form from their solutions and change night into day;" and yet, as he went on to point out, this is not less the time "when the world-encompassing telegraph no longer suffices for the needs of intercourse, but must give place to the transmission of oral messages by the telephone over distances, in comparison with which the natural range of the human voice appears as nothing; when the latest fruit of the union of science and technology—electro-mechanics—in its rapid development, offers to mankind ever new and immeasureable fields for investigation and utilization of the natural forces."

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We are dealing, however, with the immediate present, and have to keep pace with such a rapidity of achievement that our plans each day have to be adjusted to larger conceptions and wider horizons. The position was admirably described this month in a leading magazine, by Mr. Geo. B. Prescott, Jr. "The improvements of methods," he said, "the refinement of machines and appliances, and the bringing of science down to daily work and business, moves on so swiftly that the new machine, or the new one of a year ago, is already old. The reduction of refractory ores in electric furnaces, where immense carbons, fed by the largest dynamos in the world, give a heat never used before, excited world-wide wonder only a few months since. * * * * Even the very recent railroad accident in Vermont has created a demand for storage batteries for lighting lamps in cars that is so active that every railroad shop in the land is examining new accumulators. Never in the history of any business was there such an eager desire to obtain new machines, new tools, and new methods as in the manufacture of electrical apparatus." This is well put. In fact, the electrical statistics of to-day are nothing short of colossal. To go no further than our own country, we find an investment and capitalization in simply the leading electrical industries—telegraphy, telephony, electric lighting, and electric power—of a sum of, at least, $350,000,000. There are in America about 700,000 miles of telegraph wire. Last year 320,000,000 telephonic conversations were held. Over 150,000 arc lamps, and incandescents verging on 1,000,000 now instruct the public eye that the electric is the light before which all others must pale their ineffectual fires. At least 10, 000 electric motors are employed in the most varied industries, and while the electric railways here are carrying passengers at the rate of more than 3½ millions annually, the extraordinary increase now going on in that branch promises that the figures will be doubled within the year, with at least from 50 to 75 electric roads in operation. When to these figures we add the thousands of dynamos and vats used in electro-plating, the countless electric appliances used, in medicine, surgery and the miscellaneous arts, and the endless variety of electrical apparatus for convenience, safety, protection and comfort in the house, office, train or hotel, we arrive at sum totals dealing with which a statistician needs all his ability to mass and classify. It is no exaggeration to say, moreover, that in the electric industries, hundreds of thousands of our most intelligent

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citizens of both sexes find remunerative and agreeable occupation; nor is it an exaggeration to affirm that at a time when all great departments of manufacture must depend for success on the degree of technical culture and skill displayed in them, none rests on a more strictly scientific basis than ours.

Where in the midst of all this activity, where in the sphere of so much outgrowth, onlook and uplift, do we find the Institute? That is the question for us to answer. The Institute has in its three years of life done good unobtrusively, but it is not discharging its reponsibilities nor carrying out its mission to the full. Our fellowship, though growing rapidly from among those already active in electrical pursuits, must be greatly enlarged to embrace the constant accessions to the electrical ranks. Cornell University alone has now 59 students in electrical engineering, and those young men as they enter on practice feel the need of association with the men already at work. Stevens Institute is sending out numbers of capable electricians, and but the other day I had the pleasure of meeting the zealous and enthusiastic "electricals" of the Massachusetts Institute of Technology. For all of them, and many others, we must provide a place in our membership.

But with an expansion of the Institute must come, as my predecessor, Mr. Pope, said last night, proper accommodation for the books, apparatus, portraits and documents of the Institute, fitting quarters for the Secretary, and a place to preserve the numerous relics and mementoes which are to be given us, but now lie dusty and neglected and widely scattered. The Institute must have a local habitation as well as a name. It should also, as suggested in a resolution adopted by you, be incorporated at as early a date as possible.

Another matter of importance is the strengthening of the ties of friendship between the Institute and kindred societies at home and abroad. We have here no end to serve but the promotion of science and industry, and to that end we are endeavoring to devote our energies with singleness of aim and purity of purpose. I would be glad to see steps taken so that any member of the electrical bodies abroad shall be entitled, while in America, to enjoy all the facilities and resources of the Institute. I would esteem it a great privilege to be in any way instrumental in more closely uniting the organizations here at home. I may particularly mention, in this respect, the New York Electrical Society, which, though local in work, is the oldest of the kind and has made a most

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creditable record. The feeling toward us on the part of that society is heartily kind and fraternal, and I do not see why the two bodies cannot be brought together, and, perhaps, by compromise and mutual concession, benefited in a close union. The first approaches have, indeed, been taken in the membership enjoyed by a great many of us in both organizations.

I might touch on other topics, but can close by one remark including them all: We have our work as a national Institute to do. It lies ready to our hands. It may not be easy of accomplishment but at least the effort can be made, and we have it in our power to render the Institute more influential, more representative, more helpful.

THE PRESIDENT:—The paper appearing first on our card programme is that by Professor Elihu Thomson; but the interest in that paper is so great that it has been thought it would be better to defer it until the afternoon session when there will be a larger attendance. We have one or two papers here from members out of town which are in the Secretary's hands and which might be taken up immediately. We will therefore have the paper by Mr. E. P. Roberts, of Cheyenne, on Practical Experience with Storage Batteries, a not less important topic and one which deserves the most careful attention of the members.

The Secretary then read the paper which is as follows:

STORAGE BATTERIES IN PRACTICE.

BY E. P. ROBERTS.

Since I had the honor of reading a paper on storage batteries at the annual meeting of 1885, we have discarded storage batteries distributed in various localities as the source of supply of current to our incandescent lamps, and have now all lamps connected with our incandescent dynamos. Having, however, a large number of cells, we have placed in position at our station about 1,200 of the same, charging them at night and using the stored current for day lighting and power, both of which are small in amount. In case of an accident to our machinery at night, we could use our storage plant to tide over the time required for repairs, or until the majority of lights could be turned off. We have not yet had a call, however, for such service, although we always have the batteries charged to a considerable extent before dark.

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Since 1885, we have tried crockery and glass cells, with plates *suspended* in the same from glass rods and separated by glass rods from each other. This was a great improvement. The cells are placed on beams of a triangular cross-section, having a four-inch base, which, in turn, rest on glass insulators, Western Union pattern, screwed on pins fastened on cross pieces. The beams are first painted and then given a coat of paraffine. The insulation from cell to cell is much improved thereby. When lead cells are used they are placed on porcelain insulators on the beams, flat places being cut on the vertical angle of the beam.

I am informed, with what degree of correctness I do not know, that storage batteries have been much improved lately over those with which I have had experience, but, even if such should be the case, I should hesitate to use them where gas lighting is cheap and where it might be desired to use only a few lights in each of a large number of localities separated by considerable distances. For special cases, however, I have no doubt the storage batteries can be used advantageously, particularly when the advantages of incandescent electric lighting are considered as being of financial value.

A few of the disadvantages arising from the conditions in the first part of the above paragraph are:

1st. A large plant in each locality is needed because of possible drain on same. The ordinary use in a residence may be 15 lamp hours and the possible use 100 lamp hours. This is an extreme example, but is not exaggerated, as it was the necessary margin we had to provide, when we had storage plants in each house requiring light, for from 15 to 20 per cent. of our customers.

If several customers can be supplied from one battery plant, the margin of extra supply can be reduced. In such case it will be necessary either to connect all the customers on all the batteries connected on multiple arc, and then disconnect the batteries and charge same in series; or, if it is desired to use a meter system in which discharge bears a certain proportion to charge, an attendant must be ready to throw extra batteries on circuit needing same, and note name of customer using extra supply.

2d. A large number of plants means a number of small stations to maintain and at which to keep supplies—distilled water, acid, etc.

3d. With a number of small stations, it is difficult to regulate E. M. F. to current desires. However small the percentage of E.

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E. M. F. lost in the discharging wires, the E. M. F. of the batteries should rise as lamps are turned on, or the lamps will be below candle-power, when a number are used, if for one or two the proper E. M. F. is used; or it will be necessary to strain the lamps when a few are used, in order to have normal brilliancy when a number are desired. To still further complicate matters, the E. M. F. is higher at the start, particularly if only a few lamps are "on," than it is later in the evening. These differences in E. M. F. are small, but are sufficient to vary the candle-power of the lamps.

If, therefore, each customer is connected with one or more batteries for his sole use the following takes place: As darkness approaches one or two lights are turned on and are raised to abnormal candle-power, straining lamps and making consumers dissatisfied with any less light later on, and as the customer's eyes become tired the light drops, possibly not below the normal candle-power, but the *comparison* is bad, and it requires considerable power of persuasion on the part of the company's "talker" and loss of his time as a "worker," to make the customer believe that his eyes are at fault and not the light. It may be that an entertainment is given in the house, and then the drop of candle-power is more noticeable, although it may not fall much below the normal.

Of course it is possible to design mechanism to overcome all such troubles, to throw in extra cells and extra batteries as required, etc. To design mechanism to accomplish such work with reliability and which will not be too costly for maintenance or prohibitory on account of excessive first cost, is considerable of a problem. Matters are further complicated by the necessary use of charging mechanism. Also, it is desirable to have switches so arranged that it will be impossible to have charging current "on" when lights are being used *from* a battery. The writer has run 1,000 lights in such a manner (with charge on) for over a year, but does not advise it from any standpoint except necessity.

If a few large stations are used, the E. M. F. at same can be readily shown at main station, and regulated from same if desired, or an attendant can be sent to any station needing regulation.

My experience teaches me that if batteries can be charged under inspection and allowed to have a discharge without excessive variation in amount of same, that the batteries will give much more reliable results than in any other way. The nearer this can be approached, the more satisfactory will be the service.

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If, therefore, it seems to be advisable in any city to erect a storage battery system for general distribution, I believe it will be found best to erect a very few large battery stations at the various centres, and that the interest on the extra cost of the wire leading from the same to the lamps, over what would be necessary if each light were close to a battery, will be far more than saved in the lessening of attendance alone; and that the avoidance of other evils I have mentioned will thus be clear gain.

DISCUSSION.

THE PRESIDENT:—The paper is now open for discussion on the part of the members. Mr. Roberts's work has gone, it seems, through a considerable evolution, and has arrived at what we may term the chemistry basis. The subject was brought somewhat prominently before the National Electric Light Association at its recent meeting in Philadelphia, and I think we have more than one member present who will have some very pertinent and valuable views to express in regard to that particular development.

If I might venture to call upon any of the members, I think Mr. Mailloux is very much interested in that subject at the present time.

MR. MAILLOUX:—Mr. President and Gentlemen: I will say that it is true that I am very much interested in storage, at the same time it does not necessarily follow that I know much about it. I was very much interested in the paper prepared by Mr. Roberts, and I quite agree with him that the most promising method of employing storage in lighting large areas will be by means of a series of groups of batteries suitably located with regard to the distribution of light to a certain group and supplied from a central station. I think that it is possible to so arrange matters that we can send the energy from the central station to the various groups at a rather high potential, and then distribute it at a lower potential from these groups: in that way we shall save copper in the conductors for carrying the energy and we shall get the benefit of distribution at a low potential. In nearly all instances it is found impossible to place the charging station in the centre or equally distant from all the various groups. Usually it is found cheaper to buy land on the outskirts of a town and to establish a central station there. I know that in the case of incandescent lighting the idea of distribution by different sets of feeders has been adopted and in some cases with a marked econo

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my in the cost of conductors. I have in mind the case of a person interested in electric lighting—who submitted to me some data regarding an installation in some city in Pennsylvania, where he produced an economy of over twenty per cent. in the case of omnibus wires or feeders for the mains, by adopting the plan of distributing the energy in fractions to those mains, so to speak. Instead of using one set of feeders to distribute the energy to the mains; a set of feeders of large diameter; he found that he could save copper by using distinct sets of feeders of smaller diameter and striking the mains at a point more favorably situated with respect to the particular group of lamps; and in this way, having divided the total number of lamps into groups on the map of the city, he was enabled to distribute his conductors, and that is exactly what it is proposed to do with the storage battery. I do not think it is as yet the ideal system. It is far too young and full of deficiencies to compare with the systems that have been in use for four or five years, with very able men studying their deficiencies and seeking to remedy them. From what I know of the case, I think that I can quite heartily sympathize with Mr. Roberts in his tribulations—I have no doubt he had quite enough of them; but I think if he had seen some of the more improved forms of battery that are now in the market, perhaps his labors would have been materially lessened.

THE PRESIDENT:—This point of the utilization of storage batteries in central stations was alluded to with some degree of prominence by my colleague, Mr. Wetzler, at Philadelphia, and I think that some of the figures that he then presented would be extremely pertinent on the present occasion. There also comes in, the use of storage batteries in connection with the telegraph, which I think is very important and material. We have the precedent in England; and Mr. Hamilton has given that subject, I believe, some consideration here. Mr. Wetzler might give us those figures.

MR. WETZLER:—On the occasion that the President refers to, I brought out the fact that a company had been started at Haver ford College, Pennsylvania, to run an electric light station and to have an auxiliary storage plant. The idea was this: It is conceded that the maximum number of hours for lighting probably does not exceed four or five for incandescent lighting. During the remaining time an incandescent station is practically running considerably below its capacity. Now the argument was, that if

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any means could be devised by which a number of engines, dynamos and boilers, could be kept running practically for twenty-four hours, there would be a great saving in cost of installation and operating expenses. The way in which that was to be overcome was by the installation of storage batteries. They have a certain number of dynamos there which they keep running, I believe, some twenty hours during the day, and during the time the current is not used directly from the dynamos it is stored in the batteries and drawn upon as occasion may require. I believe there are some 600 or 1,200 cells now in operation, and I understand, too, that the distribution to individual houses has also begun —that is having a battery in each house.

THE PRESIDENT:—I think we would all very much like to hear Mr. Hamilton on the point to which I alluded—or Mr. Leonard, who is also a well-known telegraph man.

MR. HAMILTON:—So far I have had no experience at all with storage batteries; but I can say that the telegraph companies have considered the feasibility of using them, and while they have not arrived at a definite conclusion so far, it seems that the number of cells that will have to be provided will make the plant too costly to use. The question is still under consideration, however, as I said before, and after we have had a little experience, I may be able to say something on the subject. If we could connect the different potentials along one after the other in series, the same as we do with dynamos, it would be a very simple matter; but that seems to be impossible, because some of the batteries would be drawn upon much more than others. On the other hand if the wires are arranged in groups in such manner that those forming each group are approximately alike in resistance, and we use separate batteries to supply the different groups, then we would have to provide a large number of cells, this with the first cost and the wear and tear would make the whole cost out of all proportion. The battery does not appear to compare at all favorably with the dynamo. Possibly within the coming year we may be able to tell something definite in regard to it, because it is possible we shall use a few of the cells. I do not know what the experience has been in England, but I think they have only used the the battery to a limited extent there.

THE SECRETARY:—In conversation with Mr. Hamilton, I understood that one of the reasons why the dynamos were not more generally adopted for furnishing current at the large telegraph

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centres was, because there were very few places where the demand for the current was sufficient to warrant the running of the plant for twenty-four hours continuously; nor when this was done could sufficient economy be gained to make it worth while to change from the primary battery ordinarily in use to the dynamo. I would like to inquire from Mr. Hamilton, in connection with this, whether it would not be possible with the use of storage batteries to utilize the dynamos in centres where it is not now economical to run them for twenty-four hours continuously.

MR. HAMILTON:—I do not know that I get the gentleman's idea.

THE SECRETARY:—In Pittsburgh, for instance, I understand you are about putting a dynamo plant there.

MR. HAMILTON:—Yes; within the coming three months the plant will be put in there. Wherever we have from 9,000 to 10,000 cells I think it would be advisable to put in a dynamo plant. But I doubt very much whether we could do anything with a storage battery, because we must have four or five different potentials at least. This must be duplicated to get opposite polarity to line; which would be ten different batteries at once, and then you have got to include a spare afterwards, which at $17.00 or $18.00 or $20.00 a cell is rather expensive.

THE SECRETARY:—That would be a very suitable problem for Mr. Mailloux to grapple with.

MR. FRANK L. POPE:—There is another application of the storage battery which has not been discussed at this meeting, respecting which I would like to say a few words of possible interest to the members.

A short time since I was applied to by the president of a street railway company, in one of our largest cities, which is about to build a new line about five miles in length, on which it is proposed to run something like twenty cars. The gentleman came to consult me about the possibility of working the line by electricity, stating at the same time that there were insuperable objections to the use of any sort of overhead conductors, and that very serious opposition would be made to the use of a conduit or anything which would occasion the slightest disarrangement of the pavement. He therefore wished me to investigate the question of running cars by accumulators or storage batteries. In undertaking such an investigation, I examined a car which was being experimentally run on the Eighth Avenue in this city with the

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Julien accumulator, by the Julien Electric Company. I was very much more favorably impressed with the results attained than I had anticipated, although it was easy to see that much better work could be done by the system than was being done there. In the first place, of all the street railway lines in New York city the Eighth Avenue is perhaps the most miserable in its construction. Its track would hardly be tolerated on a contractor's dirt road out in the country; and yet the street railroad people in New York, who are using the most costly form of energy in the world—horse power—are wasting from half to two-thirds of it in battering their tracks and their cars to pieces against each other. There appears to be an opportunity for a good deal of missionary work in that direction, on the part of our sister society, the Civil Engineers.

To return to my subject, I made a careful investigation of the matter and procured some accumulators and had them put under test by one of our most careful and accomplished young electricians, and from the results obtained by him I became entirely convinced of the practicability of operating street cars at a cost something less than by horse power at all events, and possibly considerably less. It is difficult to arrive theoretically at the cost, because no one seems to know exactly the average power required to propel a street car. The load varies greatly at different times of the day and the resistance or traction varies widely according to the condition of the dirt on the track, whether wet or dry, and how much there is of it, so that nothing short of a series of practical experiments will give us exact results. We were, however, sufficiently encouraged to go on and have a car built, embodying all the modern improvements, with excellent running gear and highly efficient motors, and that car, I suppose will be ready for operation within two or three months. We intend to put the car into actual service, to carry passengers with it the same as the horse cars, and meanwhile to carefully observe the value of current used and of power consumed and to gather all the information we can, which will be available for general use when we get through.

I might add that our theoretical investigations indicate that with a number of cells, which can easily be put under the seats of an ordinary 16-foot street car, we may expect to run such a car something like fifty miles with one charge of the battery. This will enable us to do a full day's work of 16 to 18 hours by changing the batteries once. I shall be very glad to report the results of the experiment at some future meeting. [Applause.]

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MR. MAILLOUX :—I would like to merely make a word of comment on the remarks of our esteemed ex-President. I would submit that he could not run fifty miles with every kind of battery that is being introduced, and I think it would be better to say that with some forms of battery he could run fifty miles. There are batteries with which he could not run twenty-five miles.

THE PRESIDENT :—I presume it is understood we are speaking of the most advanced appliances.

MR. FRANK L. POPE :—I suppose one of the reasons why they employed a professional person to investigate the matter was in order that they might not get a battery that would run only twenty-five miles.

MR. EDWARD P. THOMPSON :—The success of a scheme often depends not only upon the device itself, but upon the man who has the device in charge. Perhaps no man is better acquainted with Mr. Roberts than I am, having roomed with him about three years at the Stevens Institute and worked with him in the laboratory one year. After graduating from the Institute, he took the position of an ordinary mechanic for the purpose of thoroughly learning the machinist's trade, at the tool room in the Singer factory. I happened to work there also at one time for instruction, and the men engaged there told me that they each paid a hundred dollars to learn their trade, so as to be employed at the Singer factory, whereas Mr. Roberts not only learned the trade, but was paid by the week. Further, he went to a factory for the manufacture of hats, in Newark, where he was foreman and general manager and obtained considerable experience; fitting himself in that way for the practical application of his knowledge of mechanics. He was appointed as electrical mathematician by the United States Company, the success of which is probably greatly due to his designs of dynamos and other machinery and lamps. At the Swan laboratory he was well known as a man who worked from eight o'clock in the morning to twelve at night. I learn from Cheyenne, that he has been working for a long time, for eighteen hours a day. Having all this experience, and knowing also that Cheyenne is the place where an attempt has been made to run the electric light by storage batteries, and knowing that Mr. Roberts has had such experience, seems to prove that in this case the failure was not due to the man. Mr. Roberts is also an inventor, and he has probably been able to make up for defects in any details of construction, and in that way further insuring the success of the storage system.

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THE PRESIDENT:—I was very glad to hear Mr. Thompson speak so highly of Mr. Roberts, and I think that Mr. Roberts deserves our hearty sympathy and consideration for his frankness in speaking on these topics and for the readiness with which at a distance, such as that of Cheyenne, he sends us papers and brings his work to our notice and looks to us for encouragement and information with which to develop his work in the future.

MR. THOMPSON:—I would add that Mr. Roberts was regarded by the Brush-Swan Company as the best man they knew of in the United Sates to take charge of the works at Cheyenne. He was paid a reasonable salary, and I know personally that they looked around for a great many men and tried several before they succeeded in obtaining just the man they wanted in Mr. Roberts.

THE PRESIDENT:—The next paper on the programme will be one by Prof. W. A. Anthony, of Cornell, on the Differing Temperature Coefficients of the Different Coils of a fine Rheostat.

ON THE DIFFERING TEMPERATURE COEFFICIENTS OF THE DIFFERENT COILS OF A FINE RHEOSTAT.

BY PROFESSOR W. A. ANTHONY.

The title of this paper should rather have been "A Description of Experiments by which the Differing Temperature Coefficients of the Coils of a Fine Rheostat were Discovered." I thought the experiments of sufficient interest to warrant a description, and I find, on writing the paper, that the experiments occupy the greater part of it.

In 1884, the Cornell University ordered of Latimer Clark, Muirhead and Co., of London, a fine rheostat and bridge of special construction. Among other things it was specified that the resistances of the coils of both bridge and rheostat should check among themselves to 1-100th of one per cent., and that everything should be done to make the instrument as accurate and reliable as it was possible for such an instrument to be. On its arrival it was found not to fulfill the requirements as regards accuracy, the coils differing among themselves in many cases by more than 1-10th of one per cent. It was returned to the makers for readjustment and did not come back to the University for several months. On its return it was found that the adjustment had been much improved, but still did not come within 1-100th of one per cent. It was, however, finally accepted at a reduced price, the writer proposing himself to perfect the adjustment.

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Press of other work prevented this being done, and, last November, when a problem requiring the highest attainable accuracy in the comparison of two resistances presented itself for solution, this rheostat was used for making the comparison, it being proposed to afterward determine and apply the corrections for the errors of the individual coils.

The problem was, to find by experiment the ratio of the constants of the suspended and stationary coils of the large galvanometer, a description of which has already been read before the

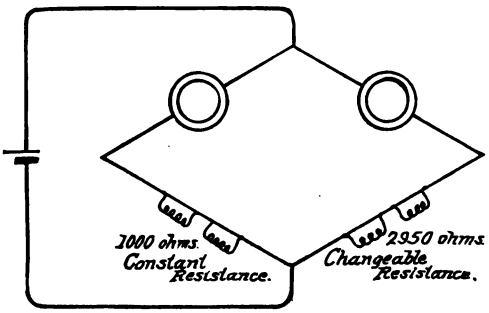

Figure 1.

Institute. The constants of these coils were determined by measurement while they were being wound and the experimental determination of the ratio was undertaken as a check on the measurements. To determine this ratio, a current is made to divide between the stationary coils on the one hand, and the suspended coil on the other, but in the reverse direction, so that the two currents shall have a differential effect on the needle. The resistances are then adjusted till the needle is unaffected when the current in both branches is reversed. The constants of the coils in the two branches are then directly proportional to the currents flowing, and, therefore, inversely proportional to the resistances of the two circuits.

To obtain the ratio of these resistances, they were arranged as two branches of a Wheatstone's bridge, as shown in figure 1, the other two branches being made up from the rheostat referred to above. The apparatus was arranged and the tests made by Mr. Ryan, a senior in electrical engineering, and Mr. Hammon, a graduate student of electrical science.

The first trials showed that nothing could be done with binding-

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screw connections and sliding contacts. All permanent connections were therefore soldered, and all others made with mercury. After this was done, irregularities still existed which were traced to varying temperatures, resulting from the fact that the building in which the galvanometer is mounted is of wood and warmed by a wood fire in an "air-tight" stove. The fire was allowed to go out, and the work continued at the temperature existing outside, about zero centigrade. Times for the experiment were chosen when the temperature was quite uniform, and the results were found to agree very well among themselves, but, to our surprise, they were totally different from the results obtained at the higher temperatures. The table below will show how the results ran.

Room warmed		No fire in room.		
Temp.	Ratio.		Temp.	Ratio.
21.4	2.9520	Dec. 7	1.7	2.9492
21.3	2.9523		1.7	2.9492
20.8	2.9529		1.8	2.9492
20.3	2.9524		1.6	2.9492
20.2	2.9526	Dec. 8	3.7	2.9495
20.2	2.9528		3.8	2.9498
19.1	2.9529		3.8	2.9497
			3.8	2.9497
			etc.	etc.

Here is a difference of one-tenth per cent. for a change of temperature of about 20 degrees centigrade. It should have been stated that the ratios above are the ratios of the two resistances as read from the rheostat; that one of the resistances was always 1,000, and of the other, which was nearly 3,000, only the units and tenths coils were changed.

A study of the construction of the galvanometer, and a discussion of the effects of temperature upon it, made it clear that the change indicated above could not be a real change in the ratio of the constants of the coils. It must, therefore, be looked for in the rheostat. To test this conclusion, different sets of rheostat coils were used in making up the arms of the balance, and tried at high and low temperatures. In one case the ratio was apparently larger at the lower temperature, the reverse of the result shown in the tables above. But the crucial test was suggested and tried by Mr. Ryan. He took the rheostat out of doors and then subjected the galvanometer and all accessory apparatus, except the rheostat, to changes of temperature. The rheostat then indicated the same apparent ratio for all temperatures of the galvanometer.

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It is certain, therefore, that a change of temperature of 20 degrees causes a change in the relative resistances of two sets of coils in this rheostat to the extent of 1-10th of one per cent.; that is, the temperature coefficients of the different coils are not the same, and it is, therefore, no wonder that the makers could not adjust the resistances more accurately. Such differences of temperature coefficients might well occur if the wire of which the coils are wound was taken haphazard from different lots, made perhaps, from different lots of metal. If makers of fine instruments are not careful to select wire that is sure to of be one composition for the construction of resistance coils, it is no wonder that it is so difficult to attain to a high standard of accuracy in electrical measurements.

But there is another possible explanation for the differences found in this instrument. The low resistances are of coarse wire, and this, from different temper or from different treatment in drawing, might not have the same coefficient., although made from the same metal, as the fine wire. In short, I believe that, for the construction of an accurate rheostat, the coils should not only be from the same lot of metal, but should all be drawn to the same size and subjected to the same treatment while being drawn. The wire chosen should be fine enough for the coils of highest resistance, and coils of low resistance should be made by winding two or more of the same wires in multiple arc.

DISCUSSION.

MR. WALLACE :—What is the size of the wire?

PROFESSOR ANTHONY :—We never have measured the wire, it is all covererd with paraffine.

MR. FRANK L. POPE :—I would like to ask if Professor Anthony knows of any experiments with American made wire, and whether the same discrepancy is observable there.

PROFESSOR ANTHONY :—I do not know of any such experiments. It is our purpose to make an investigation of this sort; but this is all I have to report in regard to the matter at present.

THE SECRETARY :—I think Mr. Prescott is here. We should be glad to hear from him.

MR. GEO. B. PRESCOTT, JR. :—Professor Anthony states that the wire in this rheostat was of different sizes. Now, if the current passing through this wire was of the same strength in all the different coils the tendency would be to heat the thin coils more

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than the thick coils, and I suppose that would need to be eliminated.

PROFESSOR ANTHONY :—In regard to that, the current was not sufficient to heat the coils any way. I suppose the current would not have heated the coils 1-100 of a degree.

MR. SCHUYLER S. WHEELER :—The kind of current that can be used with a reflecting galvanometer is about a thousand times removed from the current that would heat the wire.

THE PRESIDENT :—It struck me that Mr. Prescott asked a very pertinent question. Could Mr. Prescott give us any definite, positive information from his own work ?

MR. PRESCOTT :—Some two or three years ago, Mr. Weston, with whom I am engaged, was making some fine measuring apparatus and he found very great difficulty in getting german silver wire at different times that was of a uniform quality. For that purpose, he made some experiments on his own account, to determine the nature of this variation and what caused it. What led to his immediately taking up the subject was a paper published a short time previously in England by Professor Bottomly, who reported the discovery, by Mr. F. W. Martins, of a new alloy which he called platinoid. He said this alloy was ordinary german silver, with one or two per cent. of tungsten added. He showed by some tests that its specific resistance was very much higher and its temperature coefficient very much smaller than german silver. I looked at his original paper and I could not find what the proportions of the german silver alloy were. I had searched through all the works previously to this on that subject that I could find, and not one of them gave the proportions of this german silver alloy, not even Matthiessen. For instance, you will find in the ordinary tables in the text-books a list of the different alloys, in which the proportions of each one are given, until you come to german silver, and there they say german silver, plain and simple, as if every one knew its proportions. In this country, I went to several of the makers of wire and asked for their proportions and they seemed to use almost everything. After Mr. Weston had heard of this alloy of tungsten, he thought he would investigate it. He made up some ordinary german silver and put some tungsten into it and kept on adding it, until he got ten per cent., and he found that it did not make any difference. But he found, by varying the proportion of the nickel, that the resistance could be made almost any-

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thing, and that the resistance of german silver is almost directly proportionate to the amount of nickel. The effect of zinc was only that of dilution, but it had a mechanical advantage in making the alloy ductile, so that it could be more easily worked. We also found that the temperature coefficient varied in the same manner, and that the greater the amount of nickel in the alloy, the smaller would be the temperature coefficient. We got results very much higher than had been obtained in England with this alloy called platinoid, which was undoubtedly a german silver alloy with a high percentage of nickel. The temperature coefficient of this high resistance alloy we endeavored to determine, but we met a difficulty with this: We had a bridge—the largest pattern made by Elliott—of very large wire and very few contacts. It is called the dial pattern, in which there is only one contact for a series of plugs. We tried to get the temperature of the room very even and we obtained some very curious results, for we found that the temperature coefficient was sometimes in the reverse direction. It decreased apparently after a certain point. But as we never could be certain of the true temperature coefficient of our bridge, we were compelled to abandon determining what the exact coefficient of the wire was; and that question of the increase of nickel increasing the resistance and decreasing the temperature coefficient we proved beyond doubt.

MR. MAILLOUX:—I think it would be of interest to have Mr. Prescott state what is the largest specific resistance he obtained with various proportions of nickel.

MR. PRESCOTT:—In the Western Union Telegraph Company, the electricians have a peculiar way of giving specific resistances. It is a very large unit easily understood and it is termed the mile ohm. It is the weight of a wire a mile long, which will give just one ohm resistance. The ordinary german silver on the market has a specific resistance of 12,000 pounds to the mile ohm; that is to say, a wire a mile long having one ohm resistance requires 12,000 pounds of metal. We found, by using an alloy of something higher than thirty per cent. of nickel, that we got a mile ohm of 38,000 pounds, something more than three times the specific resistance of the ordinary german silver on the market. The temperature coefficient, as I said before, was so small that we could not, with the apparatus that we had, determine whether there was none at all, or whether it was in the reverse direction.

THE PRESIDENT:—I think this is an extremely important topic

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and it would hardly be fair to dismiss it without having the views and opinion of the members more fully brought out. We have with us one or two gentlemen, who have some very valuable information to contribute to the purposes we are here for, which is to increase each other's fund of information. Mr. Wallace could give us some very interesting data on the subject of this wire. It is as Mr. Pope has already pointed out, somewhat significant that we are discussing an English instrument. I was very much struck by a fact which came under my notice last week, where in a city in this country of 400,000 people, an electrician doing a piece of new work was absolutely unable to obtain any number 9 iron wire and, in order to introduce resistance, took the hoops off some hay bales and used them for that purpose.

We have with us also Mr. Carl Hering, who has done, I believe, some very interesting work in that direction, and from either of these gentlemen we should be very glad to have remarks.

MR. WALLACE:—Speaking of german silver, there are all sorts of mixtures on the market, and it does not surprise me at all that you do not get two samples alike. There is another thing: You can take the same mixture and pour it at different heats and get different results from exactly the same mixture. Then you may roll it too much or you may draw it too much, and if you do not anneal it sufficiently, you can pull it apart and you will get all sorts of resistances in that way. German silver is a very uncertain metal to handle. I have made a great many tons of it and it is very difficult to get two batches alike.

MR. HERING:—I am sorry I cannot contribute to the general information on the subject. I have had very little experience with german silver other than in measuring instruments.

MR. J. A. POWERS:—I can speak very feelingly on the subject of the quality of german silver wire in the construction of the McDonald cut-outs, if you will allow me to be somewhat personal. I find that it is impossible for us to get wire that will wind twice alike. We wind it up in bands and with a certain definite number of layers. We are obliged to adhere rigidly to a certain routine, in order to produce certain results, and all coils are wound up and measured at the same time; and we find that doing the best we can, we will have more or less variations of the wire. We have been to many different manufacturers for our wire and have been very careful about the gauge, and more careful about the temper, but it still bothers us all the time to get wire perfectly uniform.

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MR. MAILLOUX:—I can add an item of my own experience on the subject. Very recently I had occasion to use some resistance coils, made for an electrical railroad signal system, and the manufacturer showed me two bobbins that he had wound; I think that it was intended to use a resistance of twenty ohms and he was to use No. 18 wire to wind it. He showed me a bobbin which was wound with that resistance, and another one on which he said he had to take a No. 20 wire in order to get the resistance, and then he could not get it. He wound it until the bobbin was full with No. 20 wire, and even then could not get the required resistance. I have no doubt there must have been twice the weight of wire, and of a much finer size than on the other bobbin, and yet he did not have the necessary twenty ohms. That would show the great difference of specific resistance of the various samples of german silver as we find them in the market; and it would be very desirable to have researches prosecuted on the subject, so as to have some definite understanding arrived at, which would guide manufacturers in the making of german silver of a standard resistance. It is of the utmost importance to us as practical men to be reasonably certain of the grade of wire we are using. In a great many instances I find that I have a limited space in which to put a given resistance; and if the wire is not right as in this case, it becomes a matter of great difficulty to accomplish the result sought for. I would like to have Mr. Prescott state for our information, and give it as a matter of record, whether he advises the construction of rheostats for measuring purposes, made of wire, having such a high resistance; and also whether such wire can be had in the market.

MR. PRESCOTT:—I would say the higher the specific resistance and the lower the temperature coefficient the better adapted the wire is for use in rheostats. The wire can be handled and is not too brittle. All the wire that I have used has come from the Coe Brass Company, who make it according to specifications.

CAPT. MICHAELIS:—I cannot contribute anything to the knowledge of the subject, in the way of any special investigation pertaining to the matter under discussion. But I would like to call the attention of the Institute to something that has struck me in this discussion which may have a bearing on this matter and which shows the interdependence of all these investigations. The question of the wire winding of guns has been a very important one in the last ten or fifteen years, and the subject of the winding

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tension of the wire has a very important part to play in the amount of pressure brought to bear upon the core. It appears to me that in winding these coils spoken of, this fact should be taken into consideration; for no matter how small a winding tension we may have, when the very small cross-section of the wire is considered, even if it be but an ounce, but increasing directly with the area of the cross-section of the wire, you will find when you come to square inches that you have very large winding tensions to deal with. Now, in a wire wound gun, which is after all nothing but a large bobbin, we have to take into consideration the resulting pressure due to successive layers. A tube is the base of the gun, and the initial pressure on that tube is calculated; but that pressure increases constantly with the number of windings on it. In this investigation of the amount of pressure, we use the ordinary formula in regard to a cylinder, subjected to a uniform fluid pressure where the pressure produced at any point—if I recollect right—is equal to the thrust divided by the radius. Now, say you have wound the coil to a certain radius, your successive wires that are brought around it will exert, entirely as a result of the winding tension, a definitive amount of pressure on the layers that are already there. In other words, suppose you wound your bobbin one-half, you can consider that half-wound bobbin as a new core, which will be compressed, which will be subjected to a very high pressure, merely as a result of the winding tension of the wire; and I would like to ask some of the learned gentlemen who have given this matter consideration, whether the effect of that winding tension in producing pressure, and of course consequently changing the mechanical condition of the wire, has been considered in these investigations.

MR. MAILLOUX:—I would submit that in the winding of fine wires the tension is usually made as slight as is consistent with the proper guidance of the wire in winding. In winding larger wires—dynamos for instance—a great deal of tension is placed upon the wire, and I have seen in practice the effects of that tension, where by lack of precaution in insulating the core before winding, the inner layer of the wire had become abraded, and sometimes short-circuited with the core—the result of the pressure which follows the superposition of the various layers. I do not think that the tension would figure in small coils, though I think it might have some influence in large wires; but as the increment or decrement of resistance would be so slight it would probably be neglected in

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dynamo machinery and other machinery where large wire is used.

MR. HAMILTON :—I might say in respect to Capt. Michaelis's remarks, that a report was published in the Philosophical Magazine three or four years ago, where the writer had taken quite a number of different wires and measured their resistances both before and after winding, and the differences were quite considerable. I have recognized for a long time, this point of temperature coefficient for the wire, and a number of years ago, in ordering wires for coils, I specified that the wires should be of the same quality all the way through, so I should be sure of the temperature coefficient. I also think the suggestion of Professor Anthony, that the wires should be drawn of the same size, is a very good one as is also the winding of the same in multiple arc when they are used for the lower coils or liable to have heavy currents sent through them.

PROF. ANTHONY:—There has been a good deal said in regard to the difference in different batches of german silver, and in regard to difference in temperature coefficient. We know that the temperature coefficient would vary considerably in different batches. If the resistance coils I was describing, were made from different batches of german silver, I should expect the results to be as I found them—in fact very much more variable than I found them. But if reliable makers manufacture standard instruments, such as this is, from different batches of german silver, it is a very reprehensible practice. I supposed that care would be taken to select wires which had been drawn from the same batch of metal. I do not believe, with all the care taken in the mixing of german silver, that you could get two batches that would give the same result for the temperature coefficient, and for that reason I should suppose that, in making such an instrument as this, it would be necessary to take the german silver from the same batch, and not from two batches supposed to be exactly alike. The point I wanted to make was that, as coarse wires and fine wires drawn out of the same batch may not have the same temperature coefficient, because of difference in annealing and temper; and that must be guarded against as well as difference in composition due to accidental variations. Possibly also in the annealing process, since a fine wire would have to be annealed several times over, while a coarse wire might not have to be annealed at all, a change in the proportion of the constituents might occur from oxydation of one of the metals to a greater extent than the other.

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So my suggestion was that it would be important in making fine instruments of this sort, not only to use German silver from the same batch, but to take all of the wire from the same lot and of the same size, that had been drawn at the same time, and subjected to the same pressure throughout, from the time the metal was melted until it was finally drawn in wire and covered and wound upon the coil, and then to use several of those wires in multiple arc for the coils of low resistance.

PROFESSOR THOMSON:—It occurs to me that this point might be touched—whether in winding a large wire there is not more mechanical energy expended, and a hardening or change of the molecules of the large wire, since it is wound on the same diameter as the smaller wire in making the coil. We will assume that we have a wire of a certain diameter and compare it with a wire of much smaller diameter. Now, in going around a certain arc, the metal on the half of the wire towards the centre will be compressed, while that on the exterior will be expanded, and the amount of compression and expansion, with a certain radius of winding, will be of course much greater in a coarse coil than in a coil of fine wire. This may have some bearing perhaps on the point under discussion.

MR. MAILLOUX:—With regard to the remarks made by Mr. Hamilton, about the resistance of wire before winding and after winding, I think that it is due precisely to the point mentioned by Professor Thomson, and I was going to speak of it before; but I am glad that I waited until Professor Thomson had mentioned his point, because I believe it is the explanation. I have myself noticed (altogether I have not the resources of a physical laboratory at my command) that a wire that has been wound and unwound several times has a difference in resistance, especially if it is in considerable lengths, and I thought at first that I was mistaken; but with very careful measurement I found that there was a slight difference between the two; and I cannot find it to be due to any other cause than some molecular disturbance in the wire, or possibly a slight amount of stretching.

PROFESSOR THOMSON:—Take a piece of metal and bend it on edge, and then bend it on flat, and it seems to me by that means we would arrive at the fact or not of there being a change of resistance produced by bending flatwise and on edge.

THE PRESIDENT:—We have some other important papers on the programme. The next which we shall take up will be that

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by Mr. Dugald C. Jackson, of Cornell University, on the best Ratio of the Section of a Gramme Armature to the Section of the Field Magnets.

Mr. Jackson read the following paper:

THE RELATION BETWEEN THE CROSS SECTION OF THE IRON IN ARMATURE AND FIELD OF THE GRAMME DYNAMO.

BY DUGALD C. JACKSON.

The relation between the cross section of iron in the armature core to that in the magnet limbs in a dynamo machine is an important one. On its proper adjustment, in an otherwise well-designed machine, depends the attainment of maximum efficient output per pound of wire with minimum of iron. Of two machines, designed for a given purpose, the one with a Siemens armature and the other with a Gramme ring, the path of the lines of force through the armature of the latter machine will usually be considerably longer than in that of the other. It is evident that special care should be exercised to make the Gramme armature of sufficient area of cross section, that its magnetic resistance be not increased unduly. Siemens armatures, from mechanical principles, call for a goodly amount of iron; while an increase of cross section in a Gramme armature increases mechanical difficulties considerably. Consequently Gramme armatures usually have considerably smaller cross-section than Siemens armatures, in machines intended for a similar use, magnetic conductivity being sacrificed for mechanical convenience in the Gramme. How far this sacrifice may be carried, without impairing the value of the machine, must of necessity be specially determined for each individual case.

The question of how far the characteristic, and so the output of a machine, is influenced by variations in the cross section of the armature could be determined by Hopkinson's very beautiful method of predetermining characteristics. In a machine, the outline and dimensions of which are determined by conditions imposed, the curves of magnetization, such as Dr. Hopkinson used, would be fixed for the field and air space. By plotting curves for armatures of various cross-sections, the area giving the best characteristic, and yet not unduly decreasing the internal diameter of the ring would be evident. The value of the leakage ratio v, might be estimated by Prof. George Forbes's method, if the shape of the diagrams were not too complicated.

An experimental solution of the problem for a little dynamo

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was made this term in the Physical Laboratory at Cornell University. If we had armatures for one dynamo made with cores of various cross-sections, the best section would be apparent from the characteristics. However, it is not necessary to wind the armatures, but simply to measure the number of lines of force passing through the armature for various magnetizing forces—that is, observing the data for a curve of magnetization. This may be done in several ways.

In the experiment referred to, a single turn of wire was placed around the section of the armature core perpendicular to the directions of the lines of force. This was connected with a ballistic galvanometer. The swing of the needle of the galvanometer was observed when the current was reversed in the magnetizing coils on the field. The swing was thus proportional to $2HA$; A being the area of the turn of wire, and H the induction per unit area. Knowing the magnetizing current and the corresponding swing for a number of points for each of several different armatures, the corresponding curve of magnetization may be plotted. These curves are exactly similar to the total characteristic of a series dynamo or the internal characteristic of a shunt machine.

The field of the little dynamo experimented upon is of the single horseshoe type standing upon the yoke. This is rectangular in cross section. The limbs are cylindrical and are held in place on the yoke with two pins each, the contact surfaces being perfectly plane. The yoke and limbs are of the best Norway iron. The pole pieces are of a very good quality of cast-iron and are chambered to fit the upper ends of the limbs, which enter for a length of 7 cm., making the area of contact considerably greater than the cross-section of the limbs. The cross-section of the pole pieces is much greater than that of the limbs. The bore of the pole pieces is 10.8 cm. in diameter, there being a gap at the top and bottom subtending an angle at the centre of the bore of 51 deg. The width of the surfaces on either side of the gap is .3 cm. The corners of the pole pieces are all rounded off.

Following are the dimensions:

Limbs (cylindrical).

Length	20.3	cm.
Diameter	6.35	"
Area of cross section	31.66	sq. "
Distance apart from centre to centre	17.9	"

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Yoke (rectangular).

Length	26.8	cm.
Width	8.2	"
Depth	6.9	"
Area of cross section	56.6 sq.	"

Pole pieces.

Height	10.2	cm.
Width	10.2	"
Bore	10.8	"
Mean area of cross section	——sq.	"

The magnetizing coils consist of 785 turns on each limb, making a total of 1,570 turns.

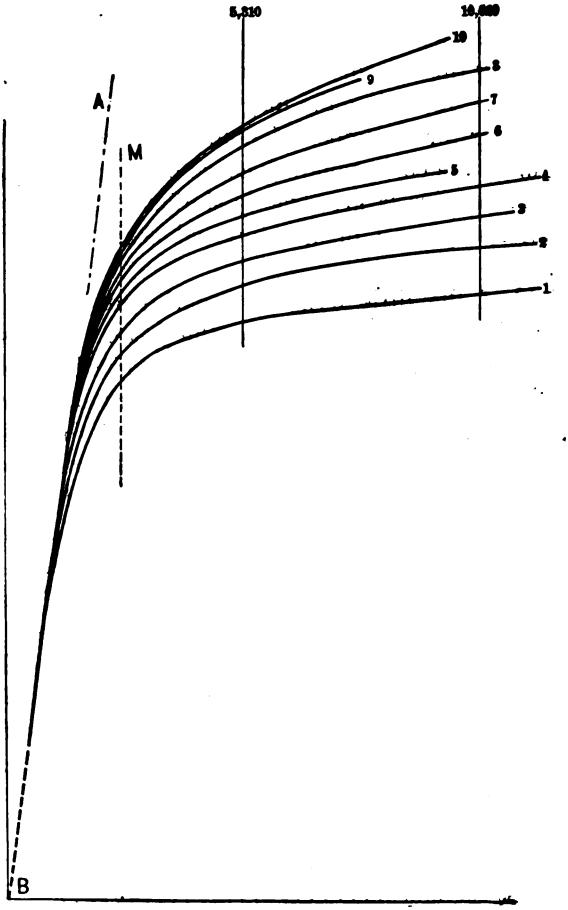

Figure 1.

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The armatures were composed of thin punched discs of soft wrought-iron obtained through the courtesy of Thos. Pray, Jr., of Hartford, Conn. The discs were insulated by dipping them into shellac varnish and then built into armatures by placing them on wooden mandrels turned to fit their internal diameter. The variation in the cross-section of the armatures was obtained chiefly by using armatures of the same number of discs, but of different internal diameters. As it was not possible to secure discs with the proper internal diameters to give all the area desired, some of the armatures were composed of fewer discs. In these, thin spaces were left between the discs, and the area inclosed by the exploring coil was slightly greater than that of the iron. The effect of this has been neglected as too small to be appreciable. The areas were obtained by multiplying the thickness of the discs, which was .0462 cm., by the number on the armature.

The magnetizing current was furnished by a number of storage cells. In the circuit of these were placed a tangent galvanometer and the magnetizing coils. A reversing key was so placed in the circuit as to simultaneously reverse the current in the galvanometer and coils. The magnetic induction was measured by a ballistic galvanometer, as already explained. The observations were taken by Mr. F. R. Jones, an engineering student working in the laboratory. The regularity of the curves attest the care with which he carried out the work. I have here a sketch, figure 1, of the curves determined by Mr. Jones, which, I think you will agree with me, are very interesting.

The following table gives the areas of the cross section of the armatures and their ratios to the cross section of the magnet limbs:

Armature	No.	1	17.75	Cm	Ratio		0.561
"	"	2	19.23	"	"		0.607
"	"	3	20.70	"	"		0.654
"	"	4	22.19	"	"		0.701
"	"	5	23.66	"	"		0.747
"	"	6	25.14	"	"		0.794
"	"	7	27.36	"	"		0.864
"	"	8	29.18	"	"		0.922
"	"	9	34.49	"	"		1.09
"	"	10	42.44	"	"		1.34

In curve No. 1, where the armature has little more than half

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the area of the limb, the turn in the characteristic is sharp and the straight line representing the upper portion of the curve is almost horizontal. The rapid and great increase of magnetic resistance shown by the curve to the right of the line *M* must be due entirely to the saturization of the armature. As the area of the armature increases, the turn in the corresponding characteristics grows into a longer sweep and the upper part of the curve takes an increasing angle with the horizontal. Curves Nos. 9 and 10 are given by armatures greater in cross section than the limb, and though there is a difference in their areas equal to a quarter of the area of the limbs, there is very little difference in the total induction passing through the armature. The curve No. 10 then probably very nearly represents the curve of magnetization of the iron in the field and the air space. The straight line, which constitutes the lower part of the characteristic, being the backbone of the curve, as it were, must very nearly represent the line of magnetic resistance of the air space. By air space I mean the space between the pole piece and armature.

Looking at the curves there, you see the armature No. 1 was highly saturated, or, in other words, had become of enormous magnetic resistance before the permeability of the field began to decrease appreciably. On the other hand, armature No. 9 has in-

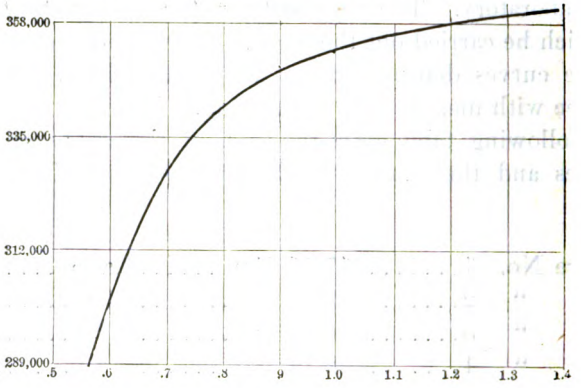

Figure 2.

creased in magnetic resistance very little up to the point to which the characteristic has been carried, while the field is quite saturated. Between these extremes there are varying degrees of relative saturization of the armature. In curve No. 7, the field and armature are apparently at about equal degrees of saturization throughout. The curve (shown in Fig. 2) illustrates the effect on the total

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induction through the armature, of the ratio of the area of the armature to that of the limbs. As ordinates are plotted total induction through the armatures taken from the characteristics on the section line *M*. The abscissas are ratios of the cross-section of the armature to that of the limbs.

This curve is exaggerated in vertical scale, so that its character may be more plainly seen. It shows obviously that the induction through the armature increased quite rapidly when the armature core was increased in area from .5 of that of the magnet limbs to about .75 that of the limbs. From .75 to .9 there is still an increase of armature core, though not so good as before, and beyond .9 the increase is of no practical importance.

If the section at *M*, Fig. 1, had been taken farther up the curves, the relative increase of total induction with increase in the area of the larger armature would not have been so marked.

The section at *M* is taken at 2,660 ampère turns; that is, an absolute magnetizing force of 33,420. The absolute total inductions for this magneto-motive force are shown in the curve, Fig. 2. These were determined by comparing the throw of the ballistic galvanometer given by the armature with that given by a standard coil turned through 180 degrees in the horizontal component of the earth's field. The value of the horizontal component at the place of the standard coil was determined by comparison with that in our magnetic observatory by the use of the compensated magnetometer.

We may safely assume that the cross-section of the armature should be about .75 of the cross-section of the limbs if the wire on the armature is to have the greatest activity without an excessive quantity of iron in the core. By making the cross-section of the armature .6 of that of the limbs, a loss of 10 per cent. of the total induction, when the ratio is .75, would be made, and consequently an equal loss in E. M. F. and the output of the machine. This is a case where the permeability of the field magnet is equal, or very nearly equal to that of the armature. If the permeability of the armature core were greater than that of the field, the area of armature could be a smaller ratio.

No allowance has been made in this for the effect of a current in the armature. That should at any rate be small, except in the case of arc-lighting machines, where a great number of turns of wire are placed on the armature with the purpose of gaining stability in the light.

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The absolute intensity of the magnetic flow per square cm. in the armature was quite high. In armature No. .5, the section of which is practically .75 that of the limbs, an induction of 14,000 per square cm. was given by 2,666 ampère turns. For about 10,000 ampère turns the induction was 17,000 per square cm, 10,000 ampère turns gave an induction of 11,000 per square cm. through armature No. 10, and about 18,000 in armature No. 1. The latter was increased to nearly 19,000 by 12,500 ampère turns.

The induction per square cm. corresponding to the best conditions in this machine is 14,000 per square cm. This is high for a dynamo. I believe Dr. Hopkinson has placed the figure in the Edison-Hopkinson machine as 8,000, and if true, this is probably seldom exceeded. I am aware that the value apparently reached 20,000 in the Manchester dynamo in Hopkinson's late tests, but that high value cannot be given much weight, even though the armature was pretty well saturated. I may be placing the limit entirely too low, as I have a number of records where from 10,000 to 15,000 is claimed, but simple claims are endowed with great uncertainty.

It may be interesting to note the ratio of the areas in two or three dynamos of ordinary size. It is impossible to estimate the area of iron in an armature with wire on it, because of the uncertainty in the space occupied by insulating material between the iron discs. In the record of their late tests, the Hopkinson's have given the areas of the armature and magnet limbs in the Edison-Hopkinson and the Manchester dynamos. In the Edison-Hopkinson machine, the field had probably nearly the same permeability as that of the armature core. The cross-section of the armature was about .8 that of the field and the field was considerably more saturated than the armature. In the Manchester dynamo the field probably had a lower permeability than the armature, and they were about equally saturated. The cross-sections of the Gramme ring in this machine was about .6 that of the cross-section of the field.

DISCUSSION.

THE PRESIDENT:—The paper is now before you for discussion. It seems to me that Mr. Jackson has thrown down two or three gauntlets that some of you should be in a position to pick up. Mr. Wheeler has done some very important work in this direction.

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MR WHEELER:—All I can say in discussing the subject is that the paper deserves the most unlimited praise. I will admit frankly that I did not expect it would, but having heard it I cannot say too much in favor of it. I think the paper is nearly perfection. I shall have to study over some of the points. I have arrived at some of the conclusions which are expressed in the diagrams, not exactly by different sources of reasoning, but by different tests; for instance using a Prony brake screwed up tight to the pulley, and an ordinary spring scale to show the pull. The pull at the periphery of the dynamo pully is the equivalent of the electromotive force; in fact in the early stages of their dynamo work some gentlemen whom I know made their electromotive force calculations entirely by the pull.

That second curve on the diagram is extremely interesting and extremely valuable. I understand, without having had enough time to digest thoroughly the important points stated, that that curve represents the effect of making changes in the cross-section of the armature; that is to say as you go to the right hand in the curve the short perpendicular line represents increase in the section of the armature core, compared with the field, and the distance up and down represen's (to speak very practically) the benefit derived. The result of the work of my friends and of myself has been that we have pitched our machine at exactly the point marked .75 of the diagram. There is no line drawn there but it is exactly at that point. We have done this after carefully studying the subject and weighing the consideration. The effect of making the section of the armature less than 75 per cent. of the section of the field magnet would be to reduce the capacity of the armature for carrying the lines of force across the field, more than we would gain armature wire space; and the effect of increasing the proportion of cross-section would be to reduce the wire space too much, so that we have found 75 per cent. to be the best proportion as Mr. Jackson points out.

The upper set of curves are also very valuable indeed, showing the actual performance of armatures of different proportions and I have listened to Mr. Jackson's paper with a great deal of interest and benefit.

PROF. THOMSON:—The subject of dynamo designing is undoubtedly one of very great importance and I have some few remarks to offer thereon, as I have designed a large number of types of dynamos and experimented with a considerably greater number.

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I think that the first thing we should settle, in dealing with this subject, is the type—what is the machine to do. If you are to run arc lights, your design must be entirely distinct and different from that which you use in running incandescent lights. The reason of that may not at first be so obvious; but if we consider the nature of an arc light, we will see it. An electric arc may be running so steadily—I speak now, of course, of the long quiet arc, what may be called the perfectly developed arc, not a hissing arc—that is a semi-incandescent light, and pertakes somewhat of the nature of an incandescent load for the machine; but a long well developed arc, with the crater fully exposed, burning quietly, possesses peculiar properties. If it is at a certain condition—10 amperes and 45 volts—and you increase the current slightly, you may convert that arc into a hissing arc abruptly with a great fall in its resistance. Now, what will be the effect if you have a machine which is worked a normal current of ten amperes on the straight part of its characteristic of that machine? You will find that the machine is not stable. The current will not stop at 10 amperes, if at this point of the current the field magnet coils, traversed by 10 amperes, do not saturate; the current in a series dynamo will continue rising, until a point is reached on the curve where the electro-motive force of the machine either drops or does not increase by the addition of current in its field magnet or exciting circuit. The consequence is that the successful arc lighting machine departs entirely from such terms as you find here. They go up to a certain point when the normal current is reached. There on the bend and a little beyond it the line dips, showing that an increased current drops the electro-motive force, and that is the condition of stability in running arc lights. The arc may be burning quietly. That will represent the wide open arc. [Illustrating.] You design your machine, we will say, with a large amount of iron in your armature and a large amount in your field; you save all the power you can; you make what may be called a very excellent type of an efficient machine and then you put on a circuit of arc lamps. You have calculated the excitation, etc. You expect to work the arc lights steadily. You find, on closing the circuit, that the carbons go apart; a tremendous roar of current comes through; the arcs draw wide open; suddenly the machine ceases to develop current—down they come and the operation is repeated continuously. The reason of that is that you have adjusted your arc lamps to run on 10 amperes,

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while your machine is not adjusted to furnish 10 amperes, and be stable under those conditions. The current is not stable until the field magnets have reached a certain degree of saturation—unless your arc lamp mechanism is extremely sensitive. Even in those conditions—I speak of course of the series machines—while the current in the field continues to increase, it causes a fall of resistance in the arc, a further increase of current, accompanied by a further increase of electro-motive force of these currents, and to such an extent that, as quickly as the arc lamp mechanism can act, it cannot get ahead of the increase of current. It is always behind time in drawing the arcs. It does not act instantaneously while its effects on the current are always headed off. Finally, there is a rupture of the whole circuit, down comes the carbon and we start again. That is a phenomenon we have met with frequently, and it comes always with an increased amount of iron beyond a certain proportion in the machine. We call it oscillating, surging or building up and dropping down—rough terms that we have used for the purpose of indicating the condition. It may be interesting to remark in this connection that we tried at one time compounding the machine and endeavoring to work it with a large amount of iron away below saturation, using a derived circuit winding to drop the curve at the proper point. Even in that case there was the same difficulty of surging or oscillation. Now, when we come to the design and construction of dynamos for incandescent lighting, or for motive power purposes, or for electric motor, then we have of course an entirely different set of conditions. Our resistance on the external circuit is not subject to this sudden drop of resistance, but demands more and more electromotive force to increase the current through it, and we have a dead resistance somewhat similar to a wire resistance. In that case you can work anywhere you please. On this line (indicating) you can work at about this point; and it may be that an explanation of some of the results Mr. Jackson has pointed out would be found in the fact that most dynamo builders prefer to work pretty low down on the curve. They do not like to buy their magnetism dearly. They would rather put in quantities of iron and diminish the copper in the field magnets, and get the magnetism at a rather low degree of saturation, and you will notice at this point that there is a very great difference. The differences begin to accumulate as you get up on that curve, so that if you are working at this point the difference is very large in relation to the amount of

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iron added; if you are working it here, the differences become less and less. But in motor work, we find by actual experience that we get very good results in constructing motors by putting in the armature core a rather larger amount of iron than has been customary. We have made the permeability of the armature very much lower than the ordinary practice of dynamo design has called for, and it is a question whether the movement in the direction of increasing the magnetic conductivity of the armature iron is not even with dynamos a proper move. The limitation to increasing the iron sections will be found between two conditions working against us, and the condition of increased output as shown by these curves working for us; that is, if we use the armature iron in larger sections. We may make it so that the changes of current increase the heat; that is the Foucault currents may trouble us; and if we make it of larger section also we increase the length of wire which is to go around it—longer turns of wire being required to cover the increased section—and those influences may be said to be working against us; so that there will be a point somewhere at which we will find the maximum conditions. In motor work our design of course is to pass as much as possible of the magnetism we develop through the armature, and the armature current itself assists us in doing that. There seems to be no reason why we should not use a comparatively large section of armature iron in a motor. We develop a field magnetism which we do not wish to have conducted out into the air and therefore we give it the best path possible through the armature. The motor would seem to be made of the best design when we have given a very ample section in the armature for the passage of the lines of force.

MR. MAILLOUX:—I would like to ask Mr. Jackson, whether his statement is that 75 $^0/_0$ sectional area is what he considers the best proportion. In my practice, whenever I have used the Gramme ring, I have always used a sectional area, at least equal to the sectional area of the limb. I did that, not because I apprehended that I needed such a large amount, but because I realized that only a portion of that sectional area can be utilized—employed usefully in conveying lines of force. Some years ago, I discussed that question through the press and called attention to what struck me then as a new way of looking at the subject, and it is this—that as the lines of force make the ring their path in passing from one pole to another, it is quite evident that the tendency

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of lines of force like other things in nature, is to take the path of least resistance—the shortest path, and consequently to crowd each other. Now it is quite plain to my mind that there must be a condition of lines of force on the periphery of the ring on the outer surface, different from what there is inside, and consequently this must mean an increased resistance of penetration. In other words the coefficient of permeability must become lower, no matter what the magnetic resistance of the iron is at the point where the lines of force enter into the core, as well as where they emerge from it; so that we might have a core of very great section, and if the magnetic density, so to speak, is very great on the outer surface, then the resistance to further penetration will be so far increased that only a portion of the sectional area will be useful in conveying lines of force. I was led to look at this from the fact that a great many builders of Gramme rings have departed from the old method of constructing the core by fine wire, wound in a solid annulus, and instead have used laminated rings of more or less thickness and separated from each other at a certain distance. Now, I have noticed, that although they get much less weight of metal in a given area of section in an armature than would be the case if they used fine wire, yet they seem to obtain very nearly as good results; and it has always been a question in my mind whether the use of laminated rings, leaving a space between did not afford better opportunities for the lines of force to seek new paths—to enter by the side of each lamina, instead of being forced to enter at the periphery. I know that there is a great deal of diversity of opinion among physicists as to the possibility of a piece of iron being saturated at one part and not magnetized at another part. I remember at the electrical conference, the statement made by Prof. Silvanus Thompson, was harshly criticised when he said the central part of a core might not be magnetized, though the outside might be saturated. I do not know on which side of the fence to stand, but I am willing to be educated on that subject. I have been told by a maker of dynamos, that taking poles of very large sectional area, he could take out the central part of it without interfering at all with the nature of his characteristic curves. Those are significant points, and some information on them would be very acceptable.

THE PRESIDENT:—We have two minutes before the lunch hour. If that time is not to be occupied by discussion, we will

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adjourn immediately, and I think, as we have so much business before us, it would be well to take simply an hour.

It was voted to take a recess for lunch, until 2 P. M.

Afternoon Session.

The President:—The business of the afternoon is to take up first some very interesting phenomena, which will be brought to our notice by Professor Elihu Thomson, on alternating currents We all listen to the professor with the utmost interest and pleasure whenever he has an opportunity to address us. I am sure that on the present occasion it will be one of extreme pleasure and profit.

NOVEL PHENOMENA OF ALTERNATING CURRENTS.

BY PROFESSOR ELIHU THOMSON.

The actions produced and producible by the agency of alternatting currents of considerable energy, are assuming greater importance in the electric arts. I mean, of course, by the term alternating currents, currents of electricity reversed at frequent intervals, so that a positive flow is succeeded by a negative flow, and that again by a positive flow, such reversals occuring many times in a second, so that the curve of current or of electromotive force will, if plotted, be a wave line, the amplitude of which is the arithmetical sum of the positive and negative maxima of current or electromotive force, as the case may be, while a horizontal middle line joins the zero points of current or electromotive force.

It is well known that such a current passing in a coil or conductor laid parallel with, or in inductive relation to a second coil or conductor, will induce in the second conductor, if on open circuit, alternating electromotive forces, and that if its terminals be closed or joined, alternating currents of the same rhythm, period or pitch, will circulate in the second conductor. This is the action occuring in any induction coil whose primary wire is transversed by alternating currents, and whose secondary wire is closed either upon itself directly or through a resistance. What I desire to draw attention to in the present paper, are the mechanical actions of attraction and the repulsion which will be exhibited between the two conductors, and the novel results which may be obtained by modifications in the relative dispositions of the two conductors.

In 1884, while preparing for the International Electrical Exhi-

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bition at Philadelphia, we had occasion to construct a large electro-magnet, the cores of which were about six inches in diameter and about twenty inches long. They were made of bundles of iron rod of about $\frac{5}{16}$ inch diameter. When complete, the magnet was energized by the current of a dynamo giving continuous currents, and it exhibited the usual powerful magnetic effects. It was found also that a disc of sheet copper, of about $\frac{1}{16}$ inch thickness and 10 inches in diameter, if dropped flat against a pole of the magnet, would settle down softly upon it, being retarded by the development of currents in the disc due to its movement in a strong magnetic field, and which currents were of opposite direction to those in the coils of the magnet. In fact, it was impossible to strike the magnet pole a sharp blow with the disc even when the attempt was made by holding one edge of the disc in

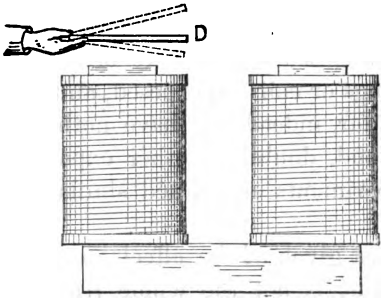

Figure 1.

the hand and bringing it down forcibly towards the magnet. In attempting to raise the disc quickly off the pole, a similar but opposite action of resistance to movement took place, showing the development of currents in the same direction to those in the coils of the magnet, and which currents, of course, would cause attraction as a result.

The experiment was, however, varied, as in figure 1. The disc *D* was held over the magnet pole, as shown, and the current in the magnet coils cut off by shunting them. There was felt an attraction of the disc or a dip toward the pole. The current was then put on by opening the shunting switch and a repulsive action or lift of the disc was felt. The actions just described are what would be expected in such a case, for when attraction took place, currents had been induced in the disc *D* in the same direction as those in the magnet coils beneath it, and when repulsion took

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place, the induced current in the disc was of opposite character or direction to that in the coils.

Now let us imagine the current in the magnet coils to be not only cut off, but reversed back and forth. For the reasons just given, we will find that the disc *D* is attracted and repelled alternately; for, whenever the currents induced in it are of the same direction with those in the inducing, or magnet coil, attraction will ensue, and when they are opposite in direction, repulsion will be produced. Moreover, the repulsion will be produced when the current in the magnet coil is rising to a maximum in either direction, and attraction will be the result when the current of either direction is falling to zero, since in the former case opposite currents are induced in the disc *D* in accordance with well-known laws; and in the latter case currents of the same direction will exist in the disc *D* and the magnet coil. The disc might, of course, be replaced by a ring of copper or other good conductor, or by a closed coil of bare or insulated wire, or by a series of discs, rings or coils superposed, and the results would be the same. Thus far, indeed, we have nothing of a particularly novel character, and, doubtless, other experimenters have made very similar experiments and noted similar results to those described.

The account just given of the effects produced by alternating currents, while true, is not the whole truth; and just here we may supplement it by the following statements.

An alternating current circuit or coil repels and attracts a closed circuit or coil placed in direct or magnetic inductive relation therewith; but the repulsive effect is in excess of the attractive effect.

When the closed circuit or coil is so placed, and is of such low resistance metal that a comparatively large current can circulate as an induced current, so as to be subject to a large self-induction, the repulsive far exceeds the attractive effort.

For want of a better name I shall call this excess of repulsive effect the "electro-inductive repulsion" of the coils or circuit.

This preponderating repulsive effect may be utilized or may show its presence by producing movement or pressure in a given direction, by producing angular deflection as of a pivoted body, or by producing continuous rotation with a properly organized structure. Some of the simple devices realizing the conditions I will now describe.

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In Fig. 2, *C* is a coil traversed by alternating currents, *B* is a

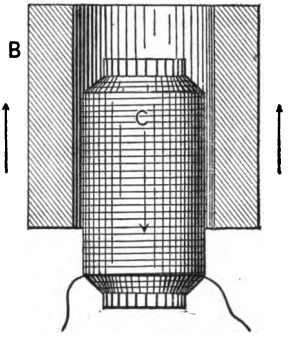

Figure 2.

copper case or tube surrounding it, but not exactly over its centre. The copper tube *B* is fairly massive and is the seat of heavy induced currents. There is a preponderance of repulsive action, tending to force the two conductors apart in an axial line. The part *B* may be replaced by concentric tubes slid one in the other, or by a pile of flat rings, or by a closed coil of coarse or fine wire insulated, or not. If the coil *C*, or primary coil, is provided with an iron core such as a bundle of fine iron wires, the effects are greatly increased in intensity, and the repulsion with a strong primary current may become quite vigorous, many pounds of thrust being producible by apparatus of quite moderate size.

The forms and relations of the two parts, *C* and *B*, may be greatly modified with the general result of a preponderance of repulsive action when the alternating currents circulate.

Fig. 3 shows the part *B* of an internally tapered or coned form, and *C* of an externally coned form, wound on an iron wire

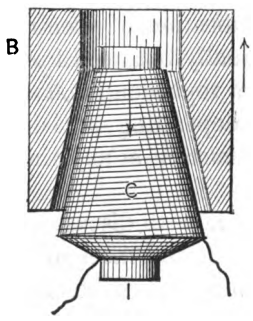

Figure 3.

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bundle *I*. The action of Fig. 2 may be said to be analagous to that of a plain solenoid with its core, except that repulsion, and not attraction is produced; while that of Fig. 3 is more like the action of tapered or conically wound solenoids and taper cores. Of course it is unnecessary that both be tapered. The effect of such shaping is simply to modify the range of action, and the amount of repulsive effort existing at different parts of the range.

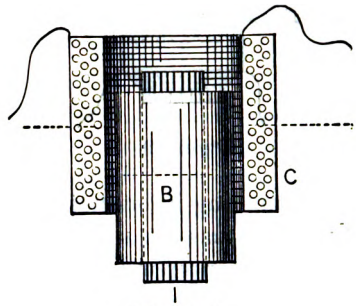

Figure 4.

In Fig. 4, the arrangement is modified so that the coil *C* is outside, and the closed band or circuit *B* inside and around the core *I*. Electro-inductive repulsion is produced as before.

It will be evident that the repulsive actions will not be mechanically manifested by axial movement or effort, when the electrical middles of the coils or circuits are coincident. In cylindrical coils in which the current is uniformly distributed through all parts of the conductor section—what I here term the electrical middle, or the centre of gravity of the ampère turns of the coils, will be the plane at right angles to its axis at its middle; that of *B* and *C* in Fig. 4 being indicated by a dotted line. To repeat, then, when the centres or centre planes of the conductors, Fig. 4, coincide, no indication of electro-inductive repulsion is given, because it is mutually balanced in all directions; but when the coils are displaced, a repulsion is manifested, which reaches a maximum at a position depending on the peculiarities of proportion and distribution of current at any time in the two circuits or conductors.

It is not my purpose now to discuss the ways of determining the distribution of currents and mechanical effects, as that would extend the present paper much beyond its intended limit. The forms and relative arrangement of the two conductors may be

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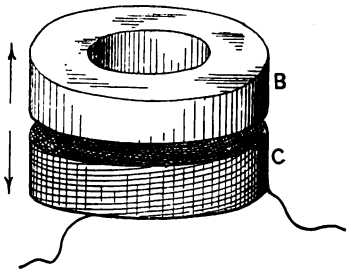

Figure 5.

greatly varied. In Fig. 5, the parts are of equal diameter, one, *B*, being a closed ring, and the other, *C*, being an annular coil placed parallel thereto, and an iron core or wire bundle placed in the common axis of the two coils increases the repulsive action. *B* may be simply a disc or plate of any form, without greatly affecting the nature of the action produced. It may also be composed of a pile of copper washers or a coil of wire, as before indicated.

An arrangement of parts somewhat analogous to that of a horseshoe electro-magnet and armature is shown in Fig. 6. The

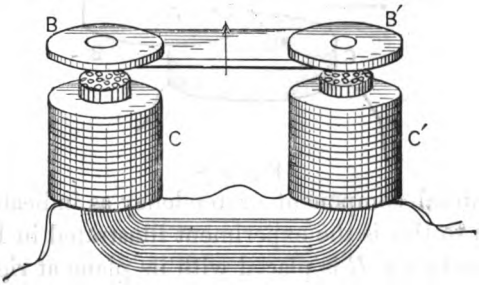

Figure 6.

alternating current coils *C C′* are wound upon an iron wire bundle bent into U-form, and opposite its poles is placed a pair of thick copper discs *B B′*, which are attracted and repelled, but with an excess of repulsion depending on their form, thickness, etc.

If the iron core takes the form of that shown by *I I*, Fig. 7, such as a cut ring with the coil *C* wound theron, the insertion of a heavy copper plate *B* into the slot or divided portion of the ring will be opposed by a repulsive effort when alternating currents pass in *C*. This was the first form of device in which I noticed the phenomenon of repulsive preponderance in question. The tendency is to thrust the plate *B* out of the slot in the ring,

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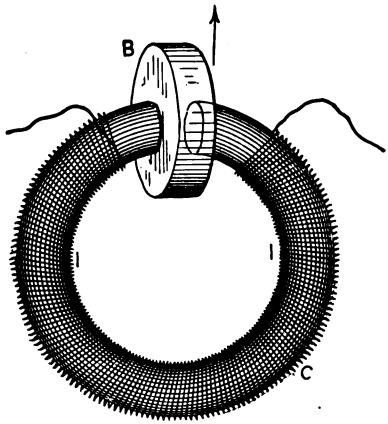

Figure 7.

excepting only when its centre is coincident with the magnetic axis joining the poles of the ring between which *B* is placed.

If the axes of the conductors, Fig. 5, are not coincident but displaced, as in Fig. 8, then, besides a simple repulsion apart,

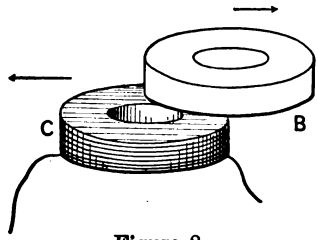

Figure 8.

there is a lateral component or tendency as indicated by the arrows. Akin to this is the experiment illustrated in Fig. 9. Here the closed conductor *B* is placed with its plane at right angles to that of *C*, wound on a wire bundle. The part *B* tends to move

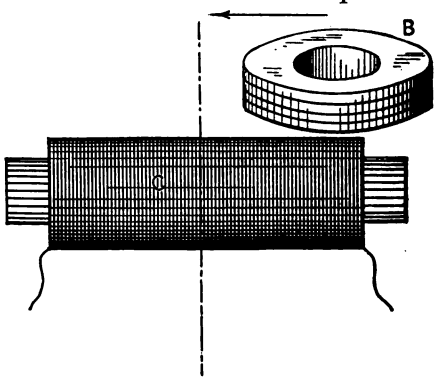

Figure 9.

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toward the centre of the coil C, so that its axis will be in the middle plane of C, transverse to the core, as indicated by the dotted line. This leads us at once to another class of actions, *i. e.*, deflective action.

When one of the conductors, as B, Fig. 10, composed of a disc, or better, of a pile of thin copper discs, or of a closed coil of wire, is mounted on an axis X transverse to the axis of coil C, through

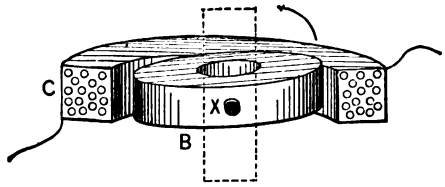

Figure 10.

which coil the alternating current passes, a deflection of B to the position indicated by dotted lines will take place, unless the plane of B is at the start exactly coincident with that of C. If slightly inclined at the start, deflection will be caused as stated. It matters not whether the coil C incloses the part B or be inclosed by it, or whether the coil C be pivoted and B fixed, or both be pivoted. In Fig. 11 the coil C surrounds an iron wire core and

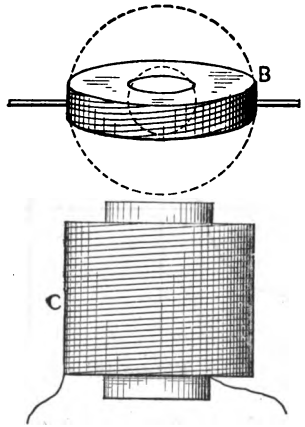

Figure 11.

B is pivoted above it, as shown. It is deflected, as before, to the position indicated in dotted lines.

It is important to remark here that, in cases where deflection is to be obtained, as in Figs. 10 and 11, B had best be made of a

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pile of thin washers or a closed coil of insulated wire instead of a solid ring. This avoids the lessening of effect which would come from the induction of currents in the ring B in other directions than parallel to its circumference.

We will now turn our attention to the explanation of the actions exhibited, and afterwards refer to their possible applications. It may be stated as certainly true that were the induced currents in the closed conductor unaffected by any self-induction, the only phenomena exhibited would be alternate equal attractions and repulsions; because currents would be induced in opposite directions to that of the primary current, when the latter current was changing from zero to maximum positive or negative current, so producing repulsion; and would be induced in the same direction when changing from maximum positive or negative value to zero, so producing attraction.

This condition can be illustrated by a diagram, Fig. 12. Here the lines of zero current are the horizontal straight lines. The

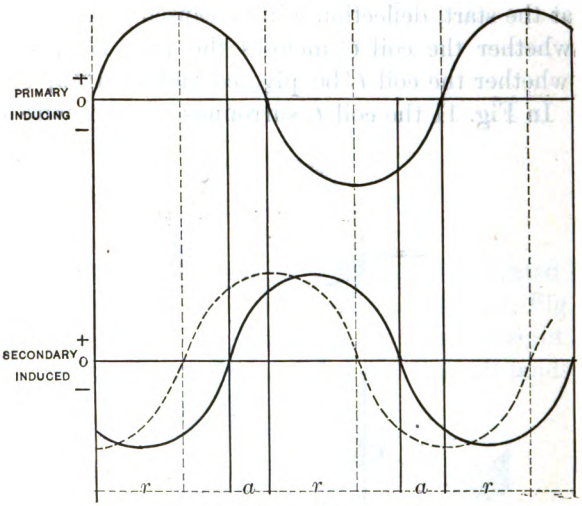

Figure 12.

wavy lines represent the variations of current strength in each conductor, the current in one direction being indicated by that portion of the curve above the zero line, and in the other direction by that portion below it. The vertical dotted lines simply mark off corresponding portions of phase or succession of times.

Here it will be seen that in the positive primary current de-

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scending from m, its maximum, to the zero line, the secondary current has risen from its zero to m^1, its maximum. Attraction will therefore ensue, for the currents are in the same direction in the two conductors. When the primary current increases from zero to its negative maximum n, the positive current in the secondary closed circuit will be decreasing from m^1, its positive maximum, to zero; but, as the currents are in opposite directions, repulsion will occur. These actions of attraction and repulsion will be reproduced continually, there being a repulsion, then an attraction, then a repulsion, and again an attraction, during one complete wave of the primary current. The letters r, a, at the foot of the diagram, Fig. 12, indicate this succession.

In reality, however, the effects of self induction in causing a lag, shift, or retardation of phase in the secondary current, will considerably modify the results and especially so when the secondary conductor is constructed so as to give to such self induction a large value. In other words, the maxima of the primary or inducing current will no longer be found coincident with the zero points of the secondary currents. The effect will be the same as if the line representing the wave of the secondary current in Fig. 12 had been shifted forward to a greater or less extent. This

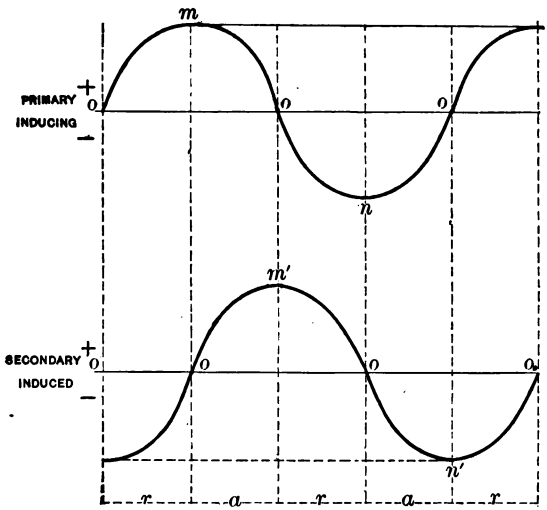

Figure 13.

is indicated in diagram, Fig. 13. It gives doubtless, an exaggerated view of the action, though from the effects of repulsion

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which I have produced I should say it is by no means an unrealizable condition.

It will be noticed that the period during which the currents are opposite, and during which repulsion can take place, is lengthened at the expense of the period during which the currents are in the same direction for attractive action. These differing periods are marked *r*, *a*, etc., or the period during which *repulsion* exists is from the zero of the primary or inducing current to the succeeding zero of the secondary or induced current; and the period during which *attraction* exists is from the zero of the induced current to the zero of inducing current.

But far more important still, in giving prominence to the repulsive effect than this difference of effective period, is the fact that during the period of repulsion both the inducing and induced currents have their greatest values, while during the period of attraction the currents are of small amounts comparatively. This condition may be otherwise expressed by saying that the period during which repulsion occurs includes all the maxima of current, while the period of attraction includes no maxima. There is then a *repulsion due to the summative effects of strong opposite currents* for a *lengthened period* against an *attraction* due to the summative effects of *weak currents* of the *same direction* during a *shortened period*, the result and effect being a greatly *preponderating* repulsion.

It is now not difficult to understand all the actions before described as obtained with the varied relations of coils, magnetic fields and closed circuits. It will be easily understood, also, that an alternating magnetic field is in all respects the same as an alternating current coil in producing repulsion on the closed conductor, because the repulsion between the two conductors are the result of magnetic repulsions arising from opposing fields produced by the coils when the currents are of opposite directions in them.

Thus far I have applied the repulsion action described in the construction of alternating current indicators, alternating current arc lamps, regulating devices for alternating currents, and to rotary motors for such currents. For current indicators, a pivoted or suspended copper band or ring composed of thin washers piled together and insulated from one another and made to carry a pointer or index, has been placed in the axis of a coil conveying alternating currents whose amount or potential is to be indicated.

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Gravity or a spring is used to bring the index to the zero of a divided scale, at which time the plane of the copper ring or band makes an angle of, say 15 degrees to 20 degrees with the plane of the coil. This angle is increased by deflection more or less great, according to the current traversing the coil. The instrument can be calibrated for set conditions of use. Time would not permit of a full description of these arrangements as made up to the present.

In arc lamps, the magnet for forming the arc can be composed of a closed conductor, a coil for the passage of current and an iron wire core. The repulsive action upon the closed conductor lifts and regulates the carbons in much the same manner that electro-magnets do when continuous currents are used. The electro-inductive repulsive action has also been applied to regulating devices for alternating currents, with the details of which I cannot now deal.

For the construction of an alternating current motor which can be started from a state of rest the principle has also been applied, and it may here be remarked, that a number of designs of such motors is practicable.

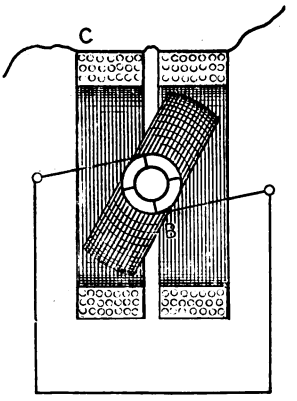

FIG. 14.

One of the simplest is as follows: The coils *C*, Fig. 14, are traversed by an alternating current and are placed over a coil *B*, mounted upon a horizontal axis, transverse to the axis of the coil *C*. The terminals of the coil *B*, which is wound with insulated wire, are carried to a commutator, the brushes being connected by a wire, as indicated. The commutator is so constructed as to

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keep the coil B on short circuit from the position of coincidence with the plane of C, to the position where the plane of B is at right angles to that of C; and to keep the coil B open circuited from the right angled position or thereabouts to the position of parallel or coincident planes. The deflective repulsion exhibited by B will, when its circuit is completed by the commutator and brushes, as described, act to place its plane at right angles to that of C, but being then open-circuited its momentum carries it to the position just past parallelism, at which moment it is again short circuited, and so on. It is capable of very rapid rotation, but its energy is small. I have, however, extended the principle to the construction of more complete apparatus. One form has its revolving portion or armature composed of a number of sheet iron discs, wound as usual with three coils crossing near the shaft. The commutator is arranged to short-circuit, each of these coils in succession, and twice in a revolution, and for a period of 90 degrees of rotation each. The field coils surround the armature and there is a laminated iron field structure completing the magnetic circuit. I may say here that surrounding the armature of a dynamo by the field coils, though very recently put forth as a new departure, was described in various Thomson-Houston patents, and to a certain extent all Thomson-Houston machines embody this feature.

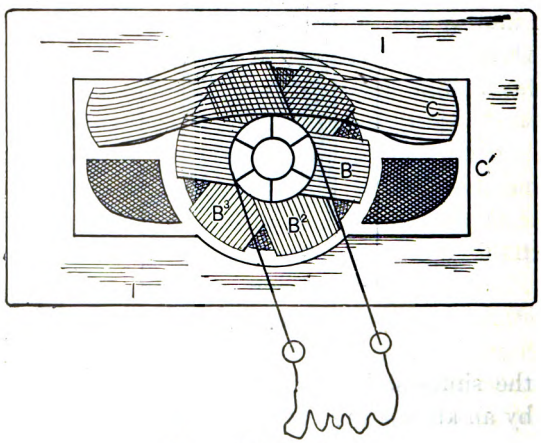

Figure 15.

Figures 15 and 16 will give an idea of the construction of the motor referred to. CC^1 are the field coils or inducing coils which

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alone are put into the alternating current circuit. *I I* is a mass of laminated iron, in the interior of which the armature revolves,

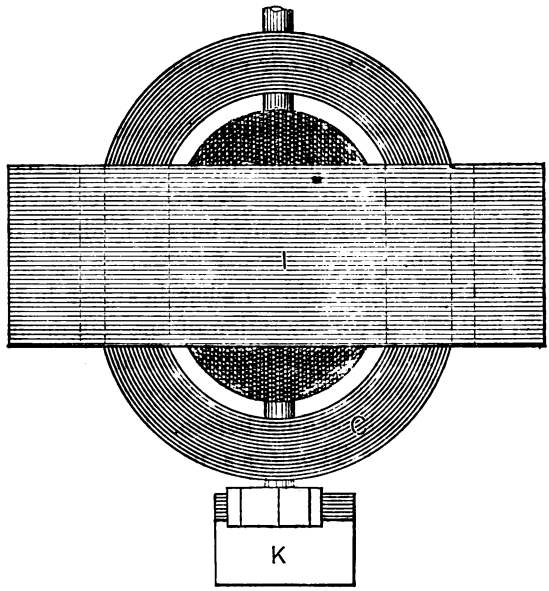

Figure 16.

with its three coils B, B^2, B^3 wound on a core of sheet-iron discs. The commutator short-circuits the armature coils in succession in the proper positions to utilize the repulsive effect set up by the currents which are induced in them by the alternations in the field coils. The motor has no dead point and will start from a state of rest and give out considerable power, but with what economy is not yet known.

A curious property of the machine is that at a certain speed, depending on the rapidity of the alternations in the coil C, a continuous current passes from one commutator brush to the other, and it will energize electro-magnet and perform other actions of direct currents. Here we have, then, a means of inducing direct currents from alternating currents. To control the speed and keep it at that required for the purpose, we have only to properly gear the motor to another of the ordinary type for alternating currents, namely, an alternating current dynamo used as a motor. The charging of storage batteries would not be difficult with such a machine, even from an alternating current line, though the losses might be considerable.

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DISCUSSION.

THE PRESIDENT:—I think we have reason to be proud of our distinguished member, and of the interest he takes in us when he presents so valuable a paper at our meeting. It is now open for discussion.

MR. WHEELER:—I was particularly interested in this, because I heard very much the same thing, or the same in its principle features described under the title of an ironclad dynamo. Of course, this is for alternating currents, but the field will be an ironclad field, or nearly so.

MR. MAILLOUX:—I might add to what has just been said by Mr. Wheeler, and also in corroboration of the statement made by Professor Thomson, that I am perfectly aware myself that the ironclad dynamo, as we have heard it called very recently, is another of those things that have been done before. I remember distinctly reading one of Professor Thomson's patents, where the direct magnetizing effect of the coil on the armature itself, is adverted to; and I do not think there can be any dispute as to the fact that it had been brought out before; and I would also state that I myself made experiments with dynamos, in which the same result was accomplished as early as 1879.

There is one interesting point that is mentioned by Professor Thomson. I think it is the phenomenon which he illustrated by means of his first figure, noting the repulsion and the attraction that take place when the current is reversed in an ordinary magnet. I could not help thinking, at the time, of some experiments made some years ago by Professors Elphinstone and Vincent, and about which I once took it into my head to write something. The fact was brought out by Messrs. Elphinstone and Vincent of the importance of the magnetic circuit that we now so well know and use in dynamo-electric machines. I had been very much struck by the statement of Faraday in his "Experimental Researches," where he speaks of lines of force expanding during the action of the beginning of current through a circuit, and of their collapse when the current is discontinued or decreased, and I remember making a note in this article (which you will find somewhere in the London *Electrician*, several years back) of experiments or observations made by me to show that that phenomenon was observable in an ordinary electro-magnet. I have been able by means of a delicately suspended needle or by a very thin piece of iron wire fast to

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the pole, so that it might place itself in the lines of force and follow the oscillations of the lines of force, to trace a positive motion in the lines of force which would be exactly corresponding with that just referred to by Professor Thomson; in a word, when the electro-magnet is in process of magnetization, when the current is passing through it,—there is an expansion of the lines of force starting apparently from the yoke, and the effect of the motion of these lines of force re-acting on the disc would be exactly such as would produce repulsion in accordance with the phenomenon of Lenz's Law. On the contrary there is a collapsing process of the lines of force in the process of demagnetization and the action would be again such as to produce attraction or the dragging of the disc with it. Now, with regard to the difference of repulsive and attractive effect, there is another fact which I think Professor Thomson has not taken into consideration and which to some extent increases the difference of repulsive effect. If we assume for a moment that the process of expansion and collapse of lines of force is true, and I have no reason to doubt that it is, then we will readily see that, as our current is put on, we are dealing with quantities. First, the resistance of the diamagnetic medium to the stress that is produced by the current, and second, the amount of energy or the rate at which we supply energy to overcome that elasticity. I might also add, of course, a third quantity, which is reaction produced by self-induction of surrounding metal; but when the collapse takes place we have the action of the pent-up energy that has been stored by the process of contraction. I might explain this by taking a piece of rubber and stretching it. The rapidity with which it is stretched depends upon the rate at which energy is applied to it and on the elasticity; but when I let go, it falls back by virtue of its own elasticity, nothing else. In the case of the secondary coil we can deal with this self-induction, but there are experiments which have been made, I think, by Professor Von Beets, which show very clearly that the impulse of collapse is much more rapid than the impulse of rise. Consequently there would be a difference of current in the inductive circuits, which would tend if we follow them carefully by means of the curves produced by Professor Thomson, to emphasize that difference of action in favor of the repulsive process. I would like to hear the views of other gentlemen, who are well informed on these subjects.

MR. PRESCOTT :—Professor Thomson has so clearly and beauti-

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fully described the experiments he has made that he has left hardly anything to be asked. I would say that I am particularly interested in the application to measuring instruments, and I would like to know whether in the application he has discovered, the repulsion is inversely proportional to the square of the distance of the plates, and if so whether he has preferred to make his instruments to measure that distance directly, or whether he has preferred to counterweight or in some way counteract the movement so as to keep it always constant.

He has paid so much attention to this question of alternating currents that I should like to ask him also whether he has made any experiments to determine, for instance, whether a secondary battery, in the circuit of an alternating current machine, would cut off a portion of the electromotive force in one direction which was counter and equal to that of the battery itself, in which case an ordinary current instrument would measure the distance if connected around the poles of the battery.

PROFESSOR THOMSON:—In regard to the measuring instruments, I have used the principle in several ways. The matter has not been carried sufficiently far as yet to determine all the points on the subject, but I have used gravity and a spring as a counterforce device. However, I find there does not seem to be any regular law, perhaps any more than there is with an electro-magnet, for the decrease of the effect by distance, except when the distances become very large. The very fact of a change of position changes the relations of the currents themselves and of the relations between the two currents, so that we can hardly regard the problem as any different from the problem of an electro-magnet attracting its armature. When the armature is placed at a certain distance, there is a certain distribution of magnetism; when it is taken to another distance the distribution is so changed that we could not consider that the centre of gravity, so to speak, of the magnetism, is the same in the two cases, and the redistribution will depend on the length, the diameter of the core and the sizes of the armatures, so that the problem becomes a very complex one. But I have made a very curious application of the principle in this way: I have taken an ordinary fruit jar and put in it a disc of a certain thickness and attached to it a bulb of glass and immersed it in alcohol or water and adjusted it, until the gravitational effect was so overcome by the flotation, that it was almost indifferent as to position, but it would just settle down to the bottom of the jar. I

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then put an alternating current coil below it and passed a current of gradually increasing amount. Gradually the disc would begin to lift itself, and at a certain current would float to a certain height, standing in the liquid supported by the repulsion. There we have a very excellent illustration and a means of getting at

Figure 17.

probably the relative repulsive effort under different conditions.

In regard to the point brough up by Mr. Mailloux, concerning the more rapid drop in the current at the end of a wave, I think that he must have been considering the effect of interrupted currents only, as in the ordinary induction coil—that is, you pass a primary current through the primary coil, as a battery current, and on closing the circuit the counter-electromotive force developed keeps down the current, and it slightly rises to that current which can pass with the electro-motive force present acting over the resistance of the primary circuit. But when you cut off the current, the secondary current is much more vigorous in electromotive force than that on making the circuit of the primary, but does not last as long. In the primary, surrounded by its secondary, when we put on the current or close the circuit, there is an opposing electromotive force; the battery does not get its full amount of current for some time, and during that time the secondary currents will seek to evolve their energy; that is, they have duration without great force. But when we cut the battery current off and do it specially with a condenser which enables us to open the contact without sparking, or in other words, to cheat the current a little and give it another path for the time being, the secondary then gives out considerable electromotive force or energy.

I may mention an interesting experiment in this connection showing the effects of self-induction in magnets—a very curious experiment tried with a large magnet. It has nothing to do with

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the repulsive effect; it has to do with self-induction and the curious effects produced by it in lagging or stopping waves and preventing waves from having their full value. We put this magnet into circuit with a dynamo and we make a shunt of carbon points—a shunting switch made with carbon contacts, as they might be placed in an arc light. The current comes through this way through the magnet coils [illustrating on the black-board], when the shunting switch is open, and goes on. We close the carbon switch, and, of course, the current gradually leaves the magnet and gradually it flows in nearly full volume over the carbon points in accordance with their resistance. If their resistance is much less than the magnet coils, nearly all the current will flow through the carbon points as a shunt. Now, on opening the carbons, the arc formed there instead of being a good, strong, full arc, will simply be the tops of the waves of the current, while a steady current will flow through the magnet. That is, you will have a steady current in the magnet, and the tops of the waves will be chopped off and sent through the carbon. There is no self-induction in this carbon branch, and the current there in the magnet branch is steady. In fact, the spark you get here at the carbons or the arc you get here will very closely resemble the spark obtained from the Rhumkorff coil—a thin spark with a considerable aureola, and not very hot. I have drawn them three-quarters of an inch long; playing and sputtering, showing that the waves of the current are having their true effect in provoking undulations of sound, whereas an ammeter put in the magnet circuit or branch shows a current pretty nearly the line current.

There was one other point on which information was asked for. It has just slipped my mind.

Mr. Prescott:—In regard to the secondary battery and the alternating current circuit.

Professor Thomson:—That is a question that I have not investigated at all, but there would be a current of double volume in one direction and a stoppage in the other direction provided the volts of counter-electromotive force were right. There is a possibility of producing a current of this character by combination of an alternating current machine and a dynamo and a continuous current machine. We may have a current like that (illustrating) produced, which would approximate the current that you were asking about. Whether applications of such currents will ever be made or not I do not know.

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MR. PRESCOTT :—The point I wanted to make is a little different. Suppose that an alternating current is passing through that wire (illustrating) and that at this point here we introduce a counter electromotive force, or a certain electromotive force in one direction, and we have a resistance in circuit with it, connected in *here*. Now, suppose this point to be shifted until the difference of potential in one direction of this alternating current is equal to the electromotive force of this opposing battery; then there will be a current of one direction only through this wire, and if that is the case having a known resistance in here you have simply to interpose an electromotive force in one direction and shift its point of contact along until you get no deflection in the galvanometer, then you would have all the data necessary to determine the electromotive force of the alternating current. Something like this was suggested to me by Mr. John Howell, of the Edison company, and he wanted me to try it. It was very recently and I have not yet had an opportunity of doing so.

THE PRESIDENT :—We have with us Mr. Pendleton, President of the New York Electrical Society, who is very much interested in this subject and we should be most happy to hear from him anything he may wish to say.

MR. PENDLETON :—I came here this afternoon more particularly to take a back seat and listen; I am grateful for the hospitality with which you have received me, and thank you for the invitation to speak upon the subject now under discussion. It is, however, not one to which I have given much thought, and it has been so thoroughly demonstrated that I feel that there is but little for me to say. In regard to the secondary battery application that the gentleman has just made, I should fancy the result would be the steady discharge of the battery of whatever charge it might have; and I believe it would be impossible to accumulate chemical energy in the battery under such circumstances. While I was listening to Professor Thomson's interesting account of his experiments, it occured to me that if the actions are sufficiently delicate, there is a great variety of applications for it, several of which he mentioned, and also that it would be possible, in connection with the telephone, to make a recording instrument, which might at any rate equal the success of the Edison phonograph. In this case it would be a reproduction of the waves of sound in the same manner. I merely make the suggestion in addition to those Professor Thomson made.

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MR. MAILLOUX :—I merely wish to ask Professor Thomson to tell us the results, if he has any, in regard to the measurement of electromotive forces of alternating currents, as the subject seems to be receiving some attention in the discussion.

MR. THOMSON :—I would be glad to give way to gentlemen who have tried to get an opportunity to say something.

MR. HERING :—I would like to ask Professor Thomson how the magnetic attraction compares with its induction. If the closed copper disc were to be made of iron, there would be attraction; now, how does that attraction compare with the repulsion in case it is not magnetic. I ask that, in order that we may get some idea of the strength of this repelling force.

PROF. THOMSON :—I have not made any determinations with that object in view—that is, to determine the relation between, as I understand it, electro inductive repulsion and the attraction of the magnet coil for its core. I think we can say, however, that it compares very well, only that the copper band, of course, naturally occupies a greater space and uses energy of current flowing in it. If we have a current flowing in a coil attracting an iron core, and the iron core is thoroughly divided so as to avoid currents in the iron itself, we would get electro-magnetic attraction pure and simple without necessary loss of energy; but in the case of the copper band there is undoubtedly, where large work is being done, a loss of energy, due to the flow of heavy currents in the conductor; but in the case of a disc which is deflected, the disc saves itself that loss by throwing itself more or less at right angles. It is only when you are resisting motion by a counter-weight that the loss amounts to much. Allow the thing to move and it relieves itself of the stress by leaving the point of greatest stress.

MR. POWERS :—I had a very interesting experience in the line of Professor Thomson's address, about the lag of heavy currents, which I wish to bring to your notice, and be somewhat personal about the matter again. At Troy, we are making an alternating current dynamo, producing direct currents from it; in other words, a simple multi-polar dynamo, with this exception, that the armatures are in two layers, the neutral point on one armature corresponding with the maximum point on the other. Those two armatures are connected to a single commutator, there being two bars connected with one armature and the next two bars with the other; the positive of one and the positive of the other, the nega-

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tive of one and the negative of the other; in that relation, a brush being put on there of a certain width, we found some curious results. With plating machines of low tension we found we could increase the width of contact to such an extent that we seemed to collect the entire current from both sides of the armature; in other words, the current seemed to be prolonged from each side of the armature so that we were practically collecting the current from both sides. The moment we got the high tension currents we failed. Without apparent lag of the current, whatever that was, the minute we increased the tension of currents up to three or four hundred volts, we failed entirely. But the point I wished to bring to your attention was that we could make that contact of considerable width and apparently get a larger power from the same amount of material in the machine, in low tension work, than we could when we got too high tension, and apparently there existed this feature of lag of heavy currents which Professor Thomson first brought up.

PROFESSOR THOMSON:—I do not think you can say that heavy currents lag any more than light currents. A heavy current is nothing more or less than the flowing around of so many lighter currents. In a closed circuit coil it is the same current going round many times, as compared we may say with many parallel currents in a band, which represent the currents that pass in a fine coil repeated side by side so many times, and the lag ought to be the same in both cases. I find, for example, that it does not matter in these experiments whether I use a copper ring or a closed coil or a finely wound coil; I might use number 36 wire, provided that I could get as much copper into the same space with the number 36 wire as I could get with a heavy mass of copper. That, of course, I cannot do; but if I could, I haven't the slightest doubt that the electromotive force currents, closed on themselves, would have the same lag as heavy currents closed on themselves. In one case there is greater length; in the other there is greater volume, both of which cause lag of the current.

Mr. Powers is probably working with high potentials in one case and quite low potentials in the other. Now, a high potential machine is a ticklish thing to handle anyhow. You must put your brushes on and carry the coil terminals away from them not a moment too late or you will have a flash and short circuit of the commutator from one point to the other. I am speaking of the type of machine to which you refer. The low potential current, how

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ever, permits us to have a considerable variation in the point of commutation, without provoking bad sparking and flashing; you no doubt are able to use an extra over-lap of brushes on the low potential machine bringing coils into action at the moment they begin to be active, or are developing very low electromotive force and taking them out of action when they are developing nearly no electromotive force. That you could not do in a machine of such type with high potentials, because if you keep the coils in beyond their time of possessing electromotive force which could just sustain the circuit, you would have a flash; there would be an alternation at the slot in the commutator which would cause a reverse current.

Mr. POWERS:—The action I was speaking of was not flashing at the commutator, but the curious growling of the machine against itself; for instance the relation between ten volts and one hundred volts on the same machine if you choose to couple them up directly, and the same brushes, would give you that slowing down and growling effect, while in the other case the brushes worked smoothly and gave good results.

PROFESSOR THOMSON:—I misunderstood the point in question.

MR. PENDLETON:—The subject has brought up a matter which was of considerable interest to me sometime ago. The different action upon the magnetization of a differential magnet in a lamp that I invented some three or four years ago, may be somewhat analogous to the action that is found in the difference between these two makes. It was an unexplained action so far as I could get at it; but some one may be able to give the reason for the fact. An ordinary differential lamp, extended poles acting upon an armature which governed the carbon rod, I ran for several weeks upon the circuit of the United States Electric Light Company to good advantage. The lamp worked well and the feeding point and polarization of the cores was correct and worked very satisfactorily. I had occasion afterwards to put the same lamp upon a high tension current and found that consequent poles were developed in the iron and the lamp although it worked, yet at the same time was working under great disadvantage. Mr. Field at the time examined the lamp; and while he spoke well of its mechanism remarked one day, "Pendleton you have got a bug in that lamp." "Well," said I, "I have, but how did you find it out?" "I had the same difficulty some years ago in meeting with consequent poles." I then told my experience with the lamp,—

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that with low tension—it ran perfectly well, and then consequent poles were not formed. I remedied it, however, by placing upon each core the two differential magnets—as it were on one spool, the coarse wire and fine wire. Now, in this action spoken of, between the high and low tension currents, I find there may be some similarity of action; and it is a matter that has not been thoroughly ventilated. I have never been able to account for it. I remedied it, but the cause of it I have never been able to ascertain. There are a great many things in the matter of magnetization, simple though it may be, that we are foggy about.

THE PRESIDENT:—We have other items on the programme, and interesting as this subject is, and attractive as it is, I think we shall have to move on. Mr. Shelbourne will you kindly take the chair.

MR. SHELBOURNE took the chair, and MR. MARTIN read the following paper, entitled, "A Few Comparative Statistics of Electrical Railways."

A FEW COMPARATIVE STATISTICS OF ELECTRIC RAILWAYS.

BY T. COMMERFORD MARTIN.

It is not now my intention to present a paper on the general subject of electric railways. That I did at a meeting of the Institute, held last December, when I was enabled to offer a few statistics on the electric railway as compared with horse, cable and other methods of traction for street cars. I have found since then a great desire generally for information as to the status of electric roads in the United States and Europe. Street railway men, investors and others have wished to know whether such a thing as an electric road was really operating anywhere or not, and, if the lines were running, what the cost of construction and operation was. The tables I submit herewith are intended as an answer to those queries. It has been difficult to get at a common basis of estimate and statement. With regard to the European roads, I would say, that I have been greatly indebted for the figures to a most admirable and exhaustive paper, read a few weeks ago by Mr. Anthony Reckenzaun, before the London Society of Arts. In Europe, as here, various systems of transmitting the current and of connecting up the motor with the car axles and wheels are in use, and as yet, no determination as to the best method seems to have been reached.

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Respecting the figures for this country, I would say that they are necessarily very much in the shape of an estimate as to the number of passengers; though, by allowing each car only 50,000 passenger a year—merely 150 a day—my calculations come out as rather low. The facts may be summed up by saying that, in Europe, the electric railways are now carrying passengers at the rate of 3,000,000 annually. In America, they are carrying at the rate of over 3,500,000, and when the roads now building are finished—to say nothing of the scores for which contracts are being made—the number carried will be at least 7,000,000 annually. When the roads at the places I enumerate in the tabular footnotes all go into operation, the number will be easily quadrupled. As to cost, I would remark that in every instance yet brought to notice, electricity has spelled economy. I saw recently some authentic and extremely elaborate statistics for 1879 of street railways and their cost in New York and Brooklyn. They were taken from the various official reports. The showing for the total cost of operation per car ranged between $8 and $10 per day at that time. The saving on that with electricity is, according to circumstances, at least 25 to 40 per cent. with heavy traffic. I have provided copies of the following tables for distribution among the audience and need not read them.

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ELECTRIC RAILWAYS IN EUROPE, APRIL, 1887.

Place.	Length.	Motors and Motor cars	No. of Passengers.	Freight.	Total Expense of operation.	Car miles run yearly.	System of Conductors.	Prime Power.
Lichterfelde-Berlin, 1881.	1½ miles.	2	100.000 yearly.				All rail.	Steam engine.
Brighton, 1883	1 mile (single track).	2	1,000,000 total.		1.92 pence per car mile.	46,950.	All rail.	Gas engine.
Moedling-Hinterbruehl, 1884.	2 8 miles (single track and sidings).	12	340,000 yearly.		3.42 pence per car mile.	91,002.	Overhead slotted tubes.	Steam engine.
Frankfort-Offenbach, 1884.	4.1 miles (double track).	14	990,000 yearly.		3.83 pence per car mile.	292,269.	Overhead slotted tubes.	Steam engine.
Zankerode (mine) 1882.	790 yards (double track).	1 locom. 16 wagons.		300 tons daily.	.77 penny per ton.	660 wagons daily.	Overhead inverted ⊥ rail.	Steam engine.
Hohenzollern (mine), 1884.	820 yards (double track).	1 locom. 15 wagons.		300 tons daily.	.5 penny per ton.	600 wagons daily.	" " "	Steam engine.
Portrush, 1883	6 miles (single track).	4	Over 100,000 up to 1885.		2½ pence per car mile.		Third rail.	Water power.
Besspool, 1885	3 miles (single track).	8	300,000 yearly.	30,000 tons yearly.	4 pence per train per mile.	60,000 train miles yearly.	Third rail.	Water power.
Blackpool, 1884	2 miles (single and double).	10	Over 1,000,000 total.		Less than 4 pence per car m.		Conduit.	Steam engine.
Brussels, 1887		5					Operated by storage batteries.	
Hamburg, 1886.		2					Operated by storage batteries.	

New Roads.—A special charter has been granted by the Austrian Government for a road in the Austrian Alps, to cost about $350,000, and to be 15 miles in length.

A road is being built in the great salt mines at Stassfurt, Germany.

The North Metropolitan Tramway Company in London has several motors now ready for use with storage batteries, on its line, awaiting powers from Parliament.

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ELECTRIC RAILWAYS

Place.	Length.	Motors and Motor Cars.	No. of passengers.	Freight.
*Baltimore, Md. 1885.....	2 miles (single track with turn outs.)	6	260,000 yearly.	.....
*Los. Angeles, Cal.. 1887.	3 miles, single and double.....	8	200,000 yearly.	.....
*Port Huron, Mich., 1885-6.....	4 miles, single track.	8	275,000 yearly.	.....
*Windsor, Can., 1885.....	Nearly 2 miles, single track.	2	200,000 yearly.	.. ..
*Highland Park, Detroit, Mich., 1886..	3½ miles, single track.	2	200,000 yearly.	.....
*Dix Road, Detroit, Mich., 1886.....	1¾ miles, single track.	4	300,000 yearly.	.....
*Appleton, Wis., 1886.....	4½ miles, single track & double	8	400,000 yearly.	.....
*Scranton, Pa., 1886	3¾ miles, single track four sidings.	3	300,000 yearly.	.....
Denver, Col., 1886..	3½ miles, single and double.	7	500,000 yearly.	....
Montgomery, Ala., 1885-86	11 miles, single and double.	18	This ran 2 cars one year. Have just started other cars. (1,000,000 yearly.)	....
†Kansas City, Mo..	....	.....	.....	... .
Orange, N. J., 1887.	½ mile built.	1	.....	.....
Boston, Mass. (sugar finery), 1887	Short track within the works.	1 locomotive, 3 cars.	.....	The cars in constant use all day; the loads averaging 10 tons per trip, and each round trip averaging 5 minutes.

*Extending line or increasing rolling stock.

New Roads—Electric railways are now in course of constructiun, or under contract, at Pittsburgh (3 roads): Los Angeles; Binghamton, N. Y., 4½ miles, 8 motor cars; Lima, O., 3 miles, 6 cars; San Diego, Cal., 9 miles, four 40 h. p. motor cars; Ansonia, Conn., 3½ miles (water power); New York city (for Fulton Street); St. Joseph, Mo., 20 ears; Mansfield, O.; Ithaca, N. Y.; Harrisburg, Pa; Woonsocket, R. I.; Richmond, Va., 40 cars, 11 miles of track.

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IN AMERICA, MAY, 1887.

Expense of operation.	Car miles run.	System of Conductors.	Prime power.
$4 per car per day.	Each motor runs 73 miles daily.	Third rail and overhead wire.	Steam engine.
....	.....	Single and double overhead wire.	Steam engine.
....	.....	Single overhead conductor.	Steam engine.
$4 per day for power.	64 miles each car per day.	Single overhead conductor.	Steam power from electric light station.
80 cents per day for fuel.	Each runs 13 hours daily; capacity 30 passengers; speed 15 miles an hour.	Sunken central rail.	Steam engine.
....	The trains run from 6 a.m. to 11 p.m.	Double overhead conductors.	Steam engine.
For power, wages of one man as they own their own water power.	17 hours daily.	Double overhead wire.	Turbine water wheels.
$9 per day for power, but are putting in their own engine.	Each car runs 85 miles per day.	Overhead wire.	Steam power from electric light station.
$1.50 per day for fuel.	.....	Conduit for series system.	Steam engine.
Fifty per cent. less than horse and mule traction—General Managers report.	....	Overhead conductor.	Steam engine.
.....	.....	.....	.....
.....	....	Overhead conductor.	Steam engine.
.....	.....	Overhead conductor.	Operated from the lighting dynamo.

†No specific details received, line not being yet in regular operation.

Companies have been formed or steps taken to build and operate electric roads at Flushing, L. I. (2); Lincoln, Neb.; Brookline, Mass. (2); East Cambridge, Mass.; Newton, Mass., Boston, Mass.; Asbury Park, N. J.; Pelham Park, N. Y.; New Brunswick, N. J.; Plainfield, N. J.; Bayonne, N. J.; Worcester, Mass.; Scranton, Pa.; Carbondale, Pa.; Philadelphia, Pa.; Reading, Pa; Bangor, Me.; Biddeford, Me.; Westfield, Mass.; Chicopee, Mass.; Muncie, Ind; Gratiot, Mich.: Tiffin, O.; Cincinnati, O.; Brooklyn, N. Y.; Coney Island, N. Y.; Rockaway, N. Y.; Winston, N. C.; Jacksonville, Fla.; Pensacola, Fla.; Birmingham, Ala.; Selma, Ala.; Atlanta, Ga.; Fort Smith, Ark.; Wichita, Kan.; San Francisco; San Jose, Cal.; Newton, Kan.

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THE CHAIRMAN:—Gentlemen, this question of electric railways is one which is very full of meat and very full of promise; it is something which it seems to me will immediately develop itself extensively, and that within the next two years we will have five times the number of electric railways in operation that are now in operation, and electric railways of more extensive routes. This morning, Mr. Frank L. Pope, our worthy past President, made some statements in regard to investigations which he had pursued with reference to that subject, and I, at that time, felt on the point of asking, as he did not state, the location of the proposed railway, nor kind of battery he had calculated upon. Whether in his calculations he took as the basis the storage battery that he had investigated, that is, the Julien battery, as I understood it, and whether he made any estimate as to the comparative percentage of cost for running a car per mile per hour with such a battery as compared with horse power.

MR. FRANK L. POPE:—In reply to the Chairman I would say that I did not mention the kind of battery used, nor the name of the railway for which we were making tests, simply to avoid the appearance of utilizing this meeting for advertising purposes; but I have no objection to making the statement. The concern referred to is the West End Street Railway Company of Boston and the battery of which we have completed a test is the Julien. I may say that we have devoted a good deal of attention to getting at, as nearly as we can, in the absence of actual experiment on the road under working conditions. The probable comparative cost of power, I think, will come to about seven cents per car mile as against ten to eleven cents per car mile by horse; experience may modify these figures; but I do not think they will be far from the true cost. We have taken great pains to get accurate data.

MR. MARTIN:—This paper is presented as a substitute for the one for which I appear upon the programme. That was to have been prepared chiefly by my associate, Mr. Wetzler, who has been sick and consequently not able to give it attention.

THE CHAIRMAN:—It seems to be necessary, gentlemen, in order to get through in time this afternoon, that we hurry on to the next paper, which is a paper by Mr. J. A. Powers, of Troy, on the installation of arc lighting plants.

MR. POWERS:—Mr. President and gentlemen, there seems to have been a pleasing variety of misunderstanding about my sub-

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ject. Arc lighting plants are included in my paper; but I had proposed to treat of the installation of central stations or rather of central station construction.

MR. POWERS then read the following paper.

CENTRAL STATION CONSTRUCTION.

BY J. A. POWERS.

There are two ways of constructing a central station for electric lighting, each of which has its special object. They may be defined as the speculative and the investment plans. The first has as its legitimate, or rather illegitimate end, the sale of the plant to some unfortunate, perhaps unwilling capitalist, by fair means or foul. We may consider as fair means the not uncommon method of selling a small portion of the stock, perhaps just enough to pay for the apparatus, on the strength of a showy exhibition in the hands of an expert, who uses all the tricks of the trade to persuade his lambs that his system will produce double the light with half the power of any other, and the other customary arguments.

The foul means is the border-ruffian money-or-your-life policy, which enters a territory already sufficiently well served, not for fair competition, but to make money by being bought out.

The electric light business is rapidly emerging from the border-ruffian and blackmailing stage; and, as we may shortly expect these methods to be relegated to their proper realm with other things dead and dishonorable, with the growth of popular knowledge of electrical matters, we will leave them, and proceed to the more legitimate methods which I hope you will all pursue.

"The fool doth think he is wise, but the wise man knows himself to be a fool," said the master of all writers; and that I may be saved entering the first class in your presence, I here confess to many and grievous mistakes in our own central station construction, to which this paper owes its being, for, that I may hope to save some of you part of my errors is my only excuse for appearing befor you.

Let us, then, drop speculation as a thing of the past in our business, and make our object the construction of such work as shall produce, in the sober judgment of every business man among you,

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the best results in economy of labor, supplies and power, with the least expenditure for interest, taxes, insurance and repairs.

In all manufacturing enterprises of the day, one tendency is unmistakably felt. It is the direction of thorough work. To succeed in any established business, one must have substantial buildings, the *best* improved machinery, the best site for obtaining necessary supplies at their cheapest. Electric lighting to-day has risen from the slough of speculation and stands side by side with other great manufacturing enterprises in importance. Not less than sixty millions of dollars are invested in lighting plants alone, and in the entire field probably not less than double that sum. Has not the time come when the same laws of strict economy which obtain in other large enterprises should govern central station construction?

Let us carefully consider our problem, plan cautiously, and expend liberally in the directions which indicate the best results. It is evident, however, that we should not expend without limit. Where shall we draw the line? I believe we are safe in expending every dollar which is sure of saving 10 per cent. interest on its investment, provided we have it to spend. The only danger in the path seems to be the chance of such improvements as shall throw aside our present methods of producing electricity. Let us for a moment consider the possibilities in this direction. The best dynamos will to-day, in ordinary practice, convert eighty to eighty-five per cent. of the power furnished them into an equivalent of electricity. Clearly there can be but small improvement here. Coal or similar fuel is the common source of power to-day, and seems likely to remain so. The best steam plants give one horse-power hour for about one and one-half pounds of coal. The actual energy stored in that one and one-half pounds of coal would give about seven horse-power hours if it could be converted into power without loss, or, in other words, the best steam plants of to-day have an efficiency of about 13 per cent.

Prof. Houston remarked, at the last convention of the National Electric Light Association, that the field where lies the greatest chance for improvement is in the direction of thermo-electricity, the conversion of heat into electricity without the intervention of power. This is most certainly so; for if a process can be discovered which will have a reasonable efficiency, say 25 per cent., electric motors must soon supersede steam engines for power. The nature of the losses connected with the conversion of heat into other forms of energy does not, however, give much encour-

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agement in this direction. The nature of such losses is in the difusion of heat by conduction and radiation, which has always proved most difficult of control. If a process of simple conversion, without the attendant development of heat, can be devised, the chances of a good efficiency would be much improved, but where heat exists, there is radiation, and where radiation is, there will be serious loss. How serious, we can only judge from our experience with the steam and other heat engines. It is probable that we are safe in investments in our expensive steam plants, at least to the extent of the life of these plants. Let us then return to our subject proper. The first matter of importance to be decided in establishing an electric light station is its location. The necessary qualifications for location may be classed about as follows:

1st. A dry soil—a gravelly soil, which will easily leach away the runnings from small drips or leaks, is preferable, next to solid rock. If located near a river, a wide margin of safety from flood should be allowed.

2d. If practicable, a location near a plentiful water supply should be chosen. Condensation of either high or low pressure engines is desirable in every way, and requires a large water supply.

3d. Nearness to the coal supply. If possible, locate, near a navigable stream, so as to secure cheapness of handling coal and a plentiful supply of water. If not near navigable water, get a location on a railroad switch, and if possible, near the water supply. If the two conditions cannot be fulfilled, you may make your choice between them, remembering that each additional handling of coal will cost about 10 cents per ton, and extra haul about 10 cents per 1,000 feet; and, on the other hand, that condensing your engines will probably save between 15 per cent. and 25 per cent. of your coal expense. The pressing necessity for locating near the lighting field has largely passed away with the introduction of long-distance systems of incandescent lighting.

Having determined on a location, the character of building to be erected must next be considered. The most important single condition essential to the success of the electric light business is continuous and reliable service to customers. The most disastrous calamity which can befall an electric lighting business, is the destruction of its central station. The first thing necessary to prevent such a calamity, is a building practically fireproof, and I believe a brick building best fulfills these conditions. Let the walls

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be bare, make all floors double planked and supported on iron beams, use no wood ceiling, however seductive it may be in improving the appearance of your station; leave as few openings as possible through the floors; have a nearly flat roof with fire walls projecting above, and the building will be as nearly fireproof as it can be, and at the same time fulfill the other essential conditions of insulation, and a reasonable expenditure of capital. Before leaving the matter of fire protection, let me strongly advocate the use of some good automatic sprinkler except in the dynamo room, and especially in parts of the building unoccupied during portions of the day, a stand pipe connected with your spare pump with nozzles on each floor, a few lengths of mill hose; a cask or two set in convenient places and kept filled with water and a few firepails near are cheaply provided, and the improvement in insurance rates will soon pay for them. At Troy, the reduction of rates has paid for the entire fire outfit in the saving in one year's premiums.

Before we design our station further, let me remark that the old adage that "cleanliness is next to godliness" would be a most wholesome motto for the electric light business. Dirt begets dirt, and with electrical apparatus it is by far the most fruitful source of short circuits, grounds, and consequently of burned armatures and disordered apparatus generally. Let us then so arrange our station that that most fruitful source of dirt, our boiler-house, may give us as little trouble as possible. Putting the boilers in the cellar and the engines and dynamos on the floor above is probably the worst possible arrangement next to putting all in the same room, since every opening in the floor conveys a blast of hot air, laden with coal dust and ashes. The correct method is to separate boiler and engine rooms by a fire wall, and make the only opening between through a room or passage through which a strong draft of air is always passing. This we effect at Troy by means of an air shaft 6 x 8 feet, which also serves as a wire tower and in which wash-sinks, etc., are also constructed. The doors, leading in both directions, are kept shut by heavy springs, and when opened the strong draft carries all dust, smells, etc., up the chimney. This shaft is carried above the roof, and the wires are carried out between the louvers of the blinds. One thing do not forget. Arrange a cellar or basement under your dynamo and engine room floor, about six feet deep. You will find it infinitely convenient in connecting small pipes, etc., to the under side of the floor.

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Make your dynamo room not less than ten feet high for the comfort of your men, and arrange the windows to open clear up to the ceiling, as that is where the hot air will go to escape. You may also put your windows six feet above the floor, and you will save annoyance from spectators, and your men will not have so much looking to do.

The boiler house should be light in construction, having an iron roof with some outside covering, such as asphalt, to prevent sweating in cold weather. The boiler fronts should, of course, face either on an open lot or a street to facilitate handling boilers, and for the same reason the front of the boiler house should be easily removable. The floor should be of concrete, not less than a foot in thickness, made of the best Portland cement, mixed about 1 part cement, 3 parts sharp sand, 3 parts stone, broken to pass 1½ inch ring.

On this may be laid a floor of flags or arch brick laid on edge. No floor of cement or of ordinary brick will stand wear.

Going back to our main building, I will follow more particularly the line of work adopted at Troy. Our lot measures 50 by 130 feet, and the problem was to develop on that space a station of a maximum capacity of 500 h. p. effective.

The lot was occupied by a mere shed, covering two 80 h. p. boilers, located almost exactly in the middle of the lot; one 150 h. p. compound engine just beside the boiler, belted to 48 feet of jack shaft lying parallel with the length of lot, and two feet six above the floor, the dynamos lying each side of the shaft, the pull of the belts being nearly balanced.

The new station was laid out in a dynamo room, 50 by 90, and boiler house, 40 by 50 feet, arranged for a battery of four boilers, 72 inches by 17 feet, stack 13 feet square at ground and 125 feet above the grates; wire tower in corner between dynamo room and boiler house, projecting into the latter. As originally laid out, the engine stood in the new dynamo room close beside the fire wall, now separating engine and boiler rooms, and the boilers further out in the dynamo room. It was decided to build the unoccupied end of the dynamo room, put in engine power connected with the old boiler, shift the station, abandon the old engine temporarily, build the rest of the new station over the old, put in new boilers, then connect them and disconnect the old boilers, remove the old boilers, and finish the inside of the building. The company changed hands on May 23d, 1885, and on September 1st the

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old station was shut down at midnight, and the dynamos shifted to the finished part of the new building, and at six the following evening the station was in full operation in its new quarters. The plant then comprised about 600 Weston incandescent lights and some 20 arc lights. The remainder of the work was merely a question of time, and the station was first operated from its new boilers on December 17th, 1885. At the same time about 15 miles of pole lines were constructed, and some 30 miles of wire strung for the city contract of 130 lights.

The general construction of the Troy station is believed to cover the average conditions met with in central station construction, and is therefore particularized. In the arrangement of dynamos and engines, we desired to obtain the best economical results in the following items:

1st. Best average economy in coal.

2d. Best average economy in transmission of power to its work.

3d. Best economy of attendance.

4th. Best economy of oil, waste, etc. Our customers required a day service, and we had to take this into account in our selection of engines for power, and in their arrangement.

These conditions were to be borne in mind in the selection of our engines, and in addition, the most important condition of reliability. Compound engines offered us the best coal economy, with maximum load, but had the disadvantage of poor economy with light loads. Corliss engines would occupy too much room, and both required shafting and counters to speed up, and would have forced us to use the second floor for dynamos, with the attending disadvantages of extra help and upright belting. We finally decided on using the best type of high-speed engines, and purchased three engines of 9x14 cylinder, each belted to a jack-shaft, 16 feet long, and each driving four 110-light incandescent dynamos, belted in pairs from opposite side of the shaft. The lengths were arranged to be coupled by friction clutches. This arrangement gave us a very uniform rate of coal economy, thought not a very high one. The arrangement of belting made the shaft friction very small. The old compound was set to work on its proper duty of driving a fixed load of city lights.

The relative merits of compound, Corliss or high-speed engines are well understood, and the circumstances must in every case decide the type of engine proper to be used.

Where the maximum of output is required for a small space,

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high speed becomes a necessity. Where the load is very variable a number of smaller engines will give as good average coal economy as a single larger engine, with less chance of a complete failure. Where the load is heavy and constant, a pair of large engines will give the best economical results and at the same time cover the possibility of a complete breakdown. The new triple expansion engines, which are rapidly replacing all others in ocean and lake steamers on account of their wonderful coal economy, will probably displace all others in the field.

Condensing high-speed engines have not met with much favor; but we find at Troy that our "Straight-line" engines work quite as quietly under 28 inches vacuum as without, and that the coal economy is considerably improved; probably from 15 to 20 per cent. on the engines condensed. They have also the advantage of giving us much more power for cases of emergency.

As to boilers, I am strongly in favor of boilers of large size; ours measure 60″x17 feet and are of Nashua "Indian head" steel, $\frac{7}{16}$ shell, $\frac{1}{2}$-inch head, and have 136 3-inch tubes. The dimensions of the tubes 3″x17 feet would be out of all proportions for ordinary drafts, but our stack 125 feet above the grates gives us ample draft and the small tubes a great evaporating surface, and consequently a better evaporation. I am afraid I shall be considered a little unsound of mind when I state that with these boilers we are able, and do, evaporate with a mixture of one part bituminous to two of yard pea and dust, nine pounds of water per pound of coal, and with ordinary buckwheat coal ten pounds of water, feed water at 200 degrees. But such is the case, as I shall be happy to show any one visiting us. This is not pounds of combustible, but of coal. I have always found the ashes to cost just as much per ton as the fuel part of the coal, and therefore consider that they have no place in the relation of evaporation per dollar. We keep a daily and nightly record of our evaporation by a Worthington meter, which is on the boiler feed; and let me say that the bad reputation for veracity of meters in general will not apply to our meter, as repeated tests show a nearly constant error of 2 per cent. low. I may further say that our meter, though a Worthington, has no connection with the *Electrical Review*. I merely state this to protect the meter from undue suspicion.

For boiler feeds, provide a reliable injector in addition to feed pump, which latter should always be used in connection with a good heater. An extra feed pump may be connected as a fire

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pump, and should be used regularly for some such service as washing out boilers, to ensure its being in good order.

Attention to surface and bottom flues is, of course, a daily duty.

As to fittings, use some one kind of valve; get a good kind and stick to it. Price should have no place in the first choice of valves. Get a good one with moveable seats and discs and you will save a world of trouble and a deal—not an electric light deal—of money in a few years time. Let me remark that everything we have in bottom blow-offs has failed, except plain plug valves. The failure seems to come from scale, which will stick under the gates and seats, and bend them out of shape when closed. An extra large valve in the blow-off discharge is desirable in case of a failure of a blow-off valve.

In piping of all kinds discard elbows and use only T's, you will frequently save taking down an entire line of pipe to make some connection by so doing, and the T's are most convenient for examining and cleaning the pipes. You should also obtain all your fittings and pipe of one party to ensure good fits. Threading tools are seldom alike and a small variation will give endless trouble with leaks.

Cover all steam pipes, and remember, in choosing a covering, that it is not the material which you cover with, which makes the non-conductor, but the confined air spaces in the same. Get air spaces and get them so arranged that the air cannot circulate between hot and cold surfaces. Remember also that you can tell nothing by the feeling of the outside of a covering about its effectiveness. Sensations of heat and cold are intensified by the conducting capacity of the object touched. A piece of metal attached to a steam covering till hot will convince you of this. It can be no warmer than the covering, but it feels so.

In touching on the electric apparatus I feel that I am treading on delicate ground, and I shall try and step accordingly. The principal elements of ordinary wear in dynamos are

1, Burned coils in the armature; 2, wear of brushes; 3, wear of commutator; 4, wear of boxes or journals.

In regard to burned armatures, I will say that judgment should be exercised in the choice of a system as to the liability of such an accident, and this being determined, choose a machine whose armature is most readily repaired. Gramme and similar ring armatures are probably the most easily repaired. Siemens arma-

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tures and all armatures with lapped coils must go to the factory for a good job.

As to brushes, the cheapest by far both in first cost and wear, is the single leaf, split brush. Multiple brushes are usually used in commutators with many segments, and there seems to be some relation between the number of segments and wear of brushes.

Commutators of many segments are less desirable than those of few. The segments can usually only be changed by putting on a new commutator and they seldom wear true. The segments on commutators of fewer bars are usually arranged to be easily removed and can then be turned up and replaced.

Plain babbitted boxes or bronze bushings are about on a par for convenience in renewal. Bronze has the advantage of not being liable to melt out and cause a shut down, and a little patience will almost always succeed in cooling them down. For belting, probably nothing is better than double pasted leather belts if well made. For large belts a few rivets must be put in.

Arc lamps should be devoid of glycerine, and not easily shaken out of adjustment. The lighter and smaller lamps are, the better for handling. Arrange all inside wiring of some first-class high insulation wire, especially on high tension circuits.

In the Keystone station in Philadelphia I first saw oil conducted to each machine oiler and cylinder cup in pipes. I heartily approve this system as a saving both of oil and waste.

In conclusion, I will suggest two rules to govern central station construction.

1. Expend every dollar which will return 10 per cent. on its investment in addition to maintaining itself, including, of course, interest, taxes and wear and tear.

2. After carefully investigating, estimating and planning out the capacity of your station, make a large guess as to what you require, and multiply by two.

THE CHAIRMAN:—A short discussion upon this paper will be in order. The subject seems to be such as to recommend itself to us all, and perhaps every body will assent to every thing that was said and will have nothing to add in the way of suggestion.

The next paper, as I understand, is on the change from negative to positive of the temperature coefficient of some carbon filaments, by Professor Anthony.

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ON THE CHANGE FROM NEGATIVE TO POSITIVE OF THE TEMPERATURE COEFFICIENT OF SOME CARBON FILAMENTS.

PROFESSOR ANTHONY:—Mr. President and Gentlemen of the Institute: I am very much chagrined as I am obliged on this occasion to ask to be excused from reading a paper. We have been at work for some time upon this matter, but have only reached some results which I will give to you in a brief way, orally.

We have not so far reached anything upon which I could make out a written paper, so I will simply state a few facts that have been reached.

We found at first in the testing of a dozen incandescent lamps for the purpose of determining their efficiency, with paper carbons and filaments—we were simply making measurements for the purpose of determining the ordinary electrical efficiency of the lamps—we found that the curve representing the relation between potential and resistance ran like this (Figure 1); the po-

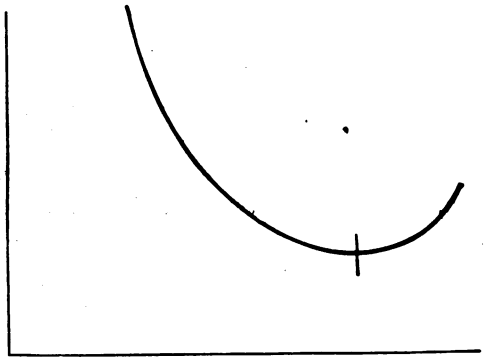

Figure 1.

tential being represented by the abscissæ and the resistance by the ordinates. Now, it had been my experience that the resistance of incandescent lamps or carbon filaments ran down when the potential ran up, and this was the first instance in which I had found an increase of resistance with rise of potential, that is, as the current and, of course, the illuminating power increased. In these particular lamps this change occurred very low in the temperature of the lamp. It occurred when in fact the lamp was only just barely red hot, and the resistance went on up to the limit to which the lamps were carried.

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Afterwards we thought this was of sufficient interest to pursue it in regard to other lamps. We have tested quite a number of lamps, and we have found in some four or five different cases, the same general results. Sometimes the curve does not change until we have reached the normal candle power of the lamp, and in many lamps we have tried, we never have reached any such change, the curve going on downward as far as the lamp could be carried, and in fact until the carbon began to disintegrate, in which case, of course, if we go back, and determine points as the potential is lowered step by step, the two curves will not coincide. We have found in some cases that the curve went down like this (Figure 1) and turned up as will be seen at the lower end of the diagram; but when we went back, we found our resistance was permanently increased on account of change in the character of carbon. But it is certain that in a number of different carbon filaments there is this change of resistance, and in all the carbon filaments that we have tried, except one or two, there is a change that indicates that at some point there would be a rise if we could carry the temperature far enough.

Now, what I hoped to be able to present to this meeting was the determination of something about the character of the carbon filaments, which showed the change early in the temperature of the lamp, where that change began at very low temperature, to determine the difference in the character between such carbon filaments; of the filaments which showed this change, and of those which did not show it and those which showed a continuous fall of resistance. That I have not been able to do. Furthermore, it was a point to determine the actual temperatures of the carbon. Those we have obtained with some degree of satisfaction; but I do not feel that our results are sufficiently trustworthy to present them.

PROFESSOR THOMSON :—The observation of Professor Anthony is quite interesting to me, because one of our men reported, two or three weeks ago, the same phenomenon as noticed in lamps; that is, that at a certain brilliancy the resistance came to a constant and then began to rise as the brilliancy was increased. I told him at the time to pursue the observation a little further and let us have some better figures. He reported to us, that all lamps did not appear to do it to the same extent.

There is another curious fact which was noticed and which has been reported to me in regard to the resistance of incandescent

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lamps. We are building lamps that are run in series on arc light circuits using $6\frac{8}{10}$ and 10 amperes, and they are put in series with the arcs and give a candle power of 32, 65 and 125. We find that when these lamps are run for a certain time, during the early part of the run—for perhaps 200 or 300 hours of the run—the resistance steadily falls. After that, it seems to steadily rise. The lamps fall in the volts which are necessary to carry the normal current through them. It does not amount to a large percentage but continues during a large fraction of the life of the lamp and after that point the resistance gradually rises. Not only has this fact been noticed in regard to lamps of large candle power and with comparatively heavy filaments of low resistance, but it has been noticed that in lamps which have been run on arc light circuits in multiple groups, the same fall and gradual increase seems to take place, and it led us to imagine that there might be some connection between the peculiarities of the arc light current itself and this effect. We have not noticed the same effects on multiple arc circuits and we have not examined very thoroughly into the matter; but we have no reason to suspect, at least not now, that this fall and gradual increase occurs on multiple arc circuits; but it seems to occur oftentimes—not always—in lamps that are put on arc lighting circuits either in groups or in series, taking the whole current.

The following paper prepared by Mr. David Brooks was then presented by the Secretary.

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LEAD ENCASED CONDUCTORS.

BY DAVID BROOKS.

In the first attempt in this country to work electric telegraphy, by Professor Morse, the wires were covered with cotton, soaked in a preparation of shellac, drawn into lead tubes four together, the intervening space being left empty.

This system was laid from Baltimore towards Washington, about five miles on the Baltimore and Ohio Railroad. I got this information from Tatham and Bros., who made most of the lead pipe purchased, although none of what they made was laid.

The experiment was a failure. About that time, or a little before, Professor Jacoby, of St. Petersburgh, undertook to lay cotton-covered copper conductors in lead pipe with the intervening space filled with rosin. There have been very many attempts of that kind which proved to be failures, until the year 1856, when the discovery of petroleum brought paraffine into the market as a cheap commercial product. This was brought to my notice, and I made many experiments to test its insulating properties, and as the result, it was taken to the patent office, and the patent awarded me, broadly, for its insulating properties.

It occurred to me that cotton-covered wires could be drawn into lead pipe, and a useful system for underground purposes accomplished, but before rushing to the patent office, specimens were buried in the yard of my factory directly under a body of water, or earth soaked with water from a hydrant. These experiments were repeated, and for a long time were attended with failure. In the journal of the *Society of Telegraph Engineers*, published in London, we find accounts of similar experiments made there with like results.

Sealing the ends of a portion of this leaded cable, coiling it up, immersing it in melted paraffine, and raising the heat to about the boiling point of water, we noticed bubbles coming out apparently from the lead. Continuing this heat until all bubbles ceased to rise and then testing the cable, we found the insulation restored. The inference was brought to my mind that the coiling and the uncoiling of lead produced such molecular changes in the metal as to make it sufficiently porous to admit moisture, and the many unsuccessful attempts to lay lead-covered cables, when the cables were insulated with paraffine, in deep water, have served to strengthen this impression.

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It must be borne in mind that paraffine, rosin, asphalt and other similar substances, in their normal condition, are brittle and the coiling and uncoiling of the lead pipe breaks them into innumerable small particles, which would leave the cable full of cracks or crevices.

These circumstances suggested the use of oil, and that brought out my system of iron tubes on account of their cheapness.

Lead covered cables are now successfully made by having the insulating material either rosin, asphalt, or pitch, mixed with oil in sufficient quantity to make the material plastic and capable of being bent without fracture.

Some of the inventors of these mixtures have repeatedly stated that their insulating material is a secret. Other materials are the subjects of patents.

Asphalt, rosin, or pitch, when mixed with oil sufficient to make them plastic but not to crack, is heavier than water, and thereby a great advantage is gained. Paraffine, either solid or liquid, is lighter than water. If solid, it cracks—if liquid, a drop of water penetrates it by reason of greater specific gravity of water.

In pursuance of the foregoing remarks, we must now look at the advantages of lead-covered conductors for all kinds of indoor purposes, or what are commonly called distributing purposes for electric lighting, etc.

An ordinary cotton-covered paraffine conductor for inside work is a dangerous thing. There has been sufficient property destroyed by the use of these cheap articles to pay five-fold the substitution for them of lead-covered conductors.

A lead-covered conductor, No. 18 gauge, may show an insulation resistance of 10,000 megohms per mile. When used for inside telephone purposes, if the lead-covering is attached to a gas or water pipe, there is perfect safety from fire from the electric current, should the outside conductor come into contact with an arc light conductor.

A copper conductor, No. 00, for arc lighting can easily be insulated when lead encased to 500 megohms per mile, and when that is brought into a building for distribution purposes, and the lead covering connected with a water or gas pipe, there is perfect safety from fire from the electric current, such as occurred at the Temple theatre in Philadelphia. Again, we can scarcely see how persons could be injured by the electric current conveyed through an insulated conductor covered with lead pipe, as was one of the

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employés of the Brush company in Philadelphia, who was killed not two weeks ago, and, since then, as another person was killed in the Adams Express building in New York.

Mr. I. N. Miller, of Cincinnati, has referred to several instances where people have been killed by taking hold of the electric light conductor covered with what is known as the underwriters' insulation, which is simply no insulation at all when exposed to dampness. As this insulation cannot be made to burn with a lighted match, it has been supposed to possess great elements of safety. But when it is encased in lead, and used for incandescent or arc lighting, a great portion of the current passes through the "insulation" to the lead covering.

Taking a piece of this underwriters' wire, covered with lead, and testing the insulation from conductor to covering with a current from a Holtz machine, you can produce no disruptive discharge, because the current passes through the "insulation" quickly, as fast as you can generate it by the machine. Take a similarly constructed lead-encased cable, properly insulated, immerse both ends of it in the insulating mixture and pass a current from the Holtz machine through naked conductors through the

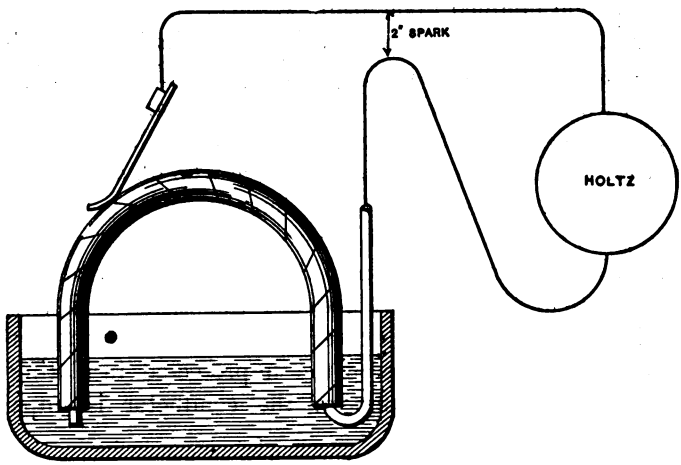

Figure 1.

air, one pole connecting with the encased conductor and the other with the lead covering, a spark two inches long will pass between the two conductors in the air before any passes between the cas-

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ing and the conductor, although the distance through the insulation is only one-eighth of an inch. The object of immersing both ends of the encased cable in the insulating material is to prevent short circuiting through the air from copper conductor to lead covering at the terminals.

Much has been said of the incombustibility of the underwriters' insulation. But it is no more incombustible than the proper insulation, provided the spark is not exposed to the air. We can make a disruptive discharge through the insulation if it be too thin, but no combustion takes place, because the air is excluded.

We can now compare this insulation with gutta-percha, caoutchouc, and their compounds.

Exposed to the air, a lead-covered conductor will last ten times as long. Besides this, when running these seam-covered conductors around right angled corners, the insulating covering is apt to open upon the outside of the bend, while a lead-covered conductor will bear much rougher usage.

This quality has been demonstrated by a lead-covered cable for telephone and telegraph, armored with iron wire, and laid across the bottom of the river Delaware between Philadelphia and Camden seven years ago, where it has worked without interruption or deterioration for all that time, although occasionally hooked up by anchors and doubled upon itself.

Other cables laid in the same locality have had frequent interruptions; some have been entirely destroyed and replaced by similar ones, which have perished in their turn, and, for aught I know, the process is still going on. However, there is another class of electricians coming upon the stage who do a little of their own thinking, and they have found out that there is both economy and good service attained by more recent devices.

There has been one objection to these lead-encased conductors, that the space *at the terminals* between the casing and the conductor is so short that, when exposed to a damp atmosphere, moisture collects upon the surface of the unprotected insulating material, and thus the insulation of the conductor is impaired.

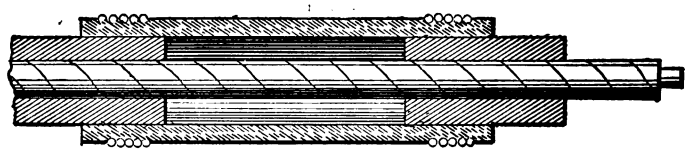

Figure 2.

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Messrs. Tatham and Bros. have a simple device by which that difficulty is completely remedied. A short section of the lead casing is cut out some inches from the terminal and an India-rubber sleeve slipped over the gap, and over both parts of the lead pipe remaining. Both ends of the sleeve are then tightly bound to the lead pipe with twine, and the insulation of the cable is safe from moisture.

ADJOURNMENT OF THE GENERAL MEETING.

THE PRESIDENT:—I think we have all had a day of great pleasure and profit, and we shall go to our regular daily duties refreshed and benefited and better able to do the work that lies before us. There being no further business a motion to adjourn is in order.

On motion of Mr. Mailloux the meeting then adjourned.

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Special Meeting.

June 28th, 1887.

The meeting was called to order at 8 P. M., at Martinelli's, 136 Fifth Avenue, New York, by the President, Mr. T. C. Martin, who announced the subject for discussion as Electric Train Lighting, and introduced Mr. George W. Blodgett, Electrician of the Boston and Albany Railroad, who had prepared a paper for the meeting.

Mr. Blodgett:—Mr. President and Gentlemen; I highly appreciate the honor you have done me in asking me to read a paper upon this somewhat new and important subject of "The Electric Lighting of Passenger Trains." It is to me, to some extent, an unsolved problem still to be worked out, so if you should say to me at the end of my paper, you are not well informed upon the subject, I should feel like saying, neither are any of us. It is in some points at least a subject of which we all know very little.

THE ELECTRIC LIGHTING OF PASSENGER TRAINS.

BY GEO. W. BLODGETT.

A better method of lighting passenger trains is demanded by considerations of economy, comfort and safety. Economy is a question which chiefly concerns the railroad management, but comfort and safety concern all its patrons. There are two ways in which we may seek these; either by improving the present system or by substituting a better one. It is doubtful whether oil lighting can be much improved and still be reasonable in cost, and whatever danger attends its use would probably still remain. I have made careful inquiry among my railroad friends without finding any instance within their personal knowledge where the ruins of a railroad wreck were set on fire by the lamps in the train (indeed these are usually instantly extinguished), but such an instance was said by one of the survivors to have occurred in the late disaster at Hartford, Vt., and another was mentioned at

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a recent meeting of the New England Railroad Club, where the explosion of a lamp set a sleeping car on fire, and it burned with nearly all the occupants. It is, however, certain that a pile of splinters deluged with oil will burn more fiercely and be much more difficult to extinguish, than if in its normal condition.

It is therefore desirable to get rid of oil lamps, for the harm they may do in *aiding* the progress of a fire, even if they do not cause one. The discomforts of oil lighting, in point of amount, distribution, unsteadiness and color of the light, corruption of the air, and the great heat given out by a large number of lamps in a car are other reasons why a change would be welcome to both the railroad management and the public, if a reliable substitute can be found. Some of the objections enumerated above apply with equal force to lighting by gas, the others are partially, but not wholly eliminated. *Electricity*, however, offers a means of lighting which comes nearer to meeting all the requirements of a perfect light for passenger cars than any other yet discovered.

There are several ways in which we may produce the electricity for car lighting. It is possible to light a car successfully by any one of them, but further experiment is necessary to determine which is the very best to adopt, and we have already found some much better adapted than others to our American trains. The different methods will be considered in order.

1. By batteries. I know only one experiment successfully going on at present. A train has been running for nearly a year between Paris and Brussels, the cars of which are lighted by electricity from a bichromate battery. It lasts for five trips of seven hours each—that is, 35 hours of lighting—without renewal, which is said to take only five minutes. No accurate estimate of cost, or more detailed information is yet at hand. There are several other batteries in the market which appear well, and if the motion of the train does not have a deleterious effect, would seem possibly adapted to this work. My own experience is conversant with only one trial of this kind which did not succeed. Forty cells of a battery which had worked well in several house installations were put in boxes suspended from the bottom of a car, and 16 lamps of 16 c. p. each, put up in the car. The lamps burned well for one night, but the next night there was the appearance of a sudden and enormous increase of internal resistance in the battery, and it was removed for further experiment before trying to light cars. An attempt was made two or three months ago, to light a

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N. Y. C. passenger car with batteries of some kind, which also failed as I am told. [Note A.]

2. By a dynamo machine. There are three ways in which this has been done. A small dynamo and engine have been mounted on the boiler or tender, and the latter run by steam from the locomotive boiler. The great objection to this method is that there is no light before the engine is attached to the train, nor if it be temporarily removed. To obviate this difficulty a separate boiler, engine and dynamo have sometimes been carried in the baggage car or on a platform car at the head of the train. It would seem that the danger from fire in this arrangement would be quite as great as by the stoves in the cars. A method tried with some success in a few instances in England and elsewhere abroad (but only once in this country to my knowledge), is to run the dynamo from one of the axles of the train, the proper speed being obtained by suitable countershafting and belts between the axle and the pulley of the dynamo. Since there would be no light when the train is at rest or when the dynamo was running at too low a speed, a battery of accumulators is added, sufficient to keep the lamps lighted for the longest time when the train is standing in the station, or elsewhere. When the train stops, or is at too low a speed for the dynamo to light all the lamps, they are automatically switched to the circuit of the accumulators where they remain till sufficient speed is again attained when they are switched back on the dynamo circuit. During the day, when the train is running, the dynamo charges the accumulators and keeps them full. They are sufficient to light the train several hours if need be. On one train, in Germany, the dynamo and 26 accumulators weighed 1,350 pounds, and cost about $625; operating about twelve lamps, cost about two cents per hour, or one-sixth of a cent per lamp per hour. The London, Brighton and South Coast Railway Co. fitted up four trains in this way. In one train of eleven cars there are thirty-two 16 c. p. lamps, absorbing forty amperes of current. The accumulators are stated to hold 500 amperes (probably 500 ampere-hours is meant), and

NOTE A.—Most batteries furnish a continuous current for so short a time without renewal, that their use is debarred on this account. Some others will not bear the shaking up produced by the motion of the train. I have myself experimented for a considerable time, but thus far without finding a battery which will run on a closed circuit longer than two or three weeks, and at the same time can be carried on a train. When such a one can be found, which at the same time gives a current strong enough to light a series of lamps, it will have a great field of usefulness.

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when fully charged are stated to be sufficient to maintain the lamps for eight hours. This train has been running since December 19th, 1883; during the first eleven months it made 2,352 trips, and ran 27,322 miles. No failures are reported. A train on the South Eastern Railway has even run a longer distance. The dynamos on these trains have an E. M. F. of 45 volts and give 56 amperes of current. Two pairs of brushes are mounted on a rocking frame, so contrived, that when the train runs in one direction, by means of a lever loosely connected with the dynamo axle, and varied in position by attraction of the pole pieces of the field magnets, it tilts the frame in the direction to bring one pair of brushes in contact with the commutator. If the train runs in the opposite direction, the other pair of brushes is brought to bear on the commutator. A vessel, containing mercury, has revolving within, a coarse threaded screw driven by a belt from the dynamo-axle. At each end of the vessel is a vertical tube, at the upper end of which is an adjustable contact screw. When the dynamo and, consequently, the screw revolves in one direction, the mercury rises in one tube. If the motion is reversed, it rises in the other tube, and when it makes contact with the adjustable screw, the shunt circuit of the dynamo is joined up, the field magnets are charged, the lever is drawn up, and one pair of brushes brought to bear on the commutator, which completes the circuit for charging the accumulators. When the lamps are lighted and the train is in motion, the dynamo feeds them, the accumulators merely acting as a regulator. If more current is being generated than the lamps require, it goes to the accumulators. If less, the balance is given out by them. When the speed of the train slackens, the fall of mercury in one of the tubes breaks contact with the adjustable screw, the field magnet circuit is broken and the brushes are removed from the commutator, the lamps continuing lighted by means of the current from the accumulators.

The apparatus can be used for several weeks with no attention beyond lubrication, and at the end of this period only a re-adjustment of the commutator brushes is necessary, which puts the machine in condition for a like longer period. The weight of the apparatus is about two tons.

The connections between the cars are made by coupling two cables together. A slightly different arrangement of circuits has the field magnets of the dynamo wound with two wires in oppo-

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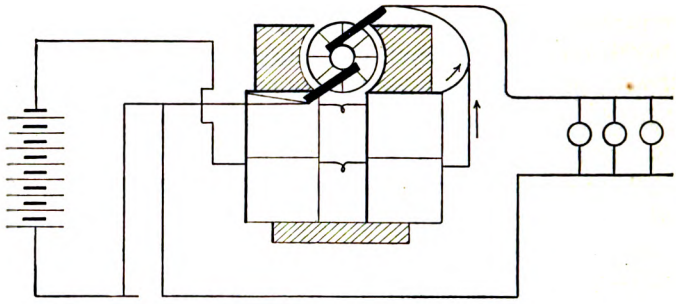
site directions, one of which is in shunt to the armature, as if the dynamo was an ordinary shunt machine. The other is wound in the reverse direction, as if the dynamo were a compound machine, and the accumulators are in series with this wire. The lamps are also in shunt with the armature.



There is a cut-out to break the circuit of the armature when the dynamo runs below a certain speed; this prevents the cells discharging themselves through it and burning it out. If the dynamo does not furnish current enough for the lamps, the accumulators supply the balance, and in doing so, strengthen the field magnets and cause an increase of current in the dynamos. When this reaches a greater amount than that needed by the lamps, the surplus goes to the accumulators, and at the same time decreases the magnetism in the field magnets so as to preserve the balance. At the maximum speed of the machine, the cells are receiving their maximum charge, and the current to the lamps is of normal amount. Two sets of brushes are here necessary, as in the other case. Mr. Barrett, of Springfield, Mass., has fitted a train of three cars on the Connecticut River Railroad, with electric lights, to be run from a dynamo in something the same way as these just described. The peculiar arrangement of the trucks under an American car renders it a matter of difficulty to obtain the proper speed of the dynamo, and I am told Mr. Barrett has had much trouble with the connections between the axle and counter-shaft. If these are not kept tight the cable slips. If too tight it breaks. An ingenious device like a friction clamp transmits the power from the counter-shaft axle to a pulley upon it. This is governed by centrifugal weights balanced by stiff springs. When the dynamo runs at its normal speed these just balance the friction of the clamp and there is no slip. Any increase of speed then causes

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the friction to diminish, and the pulley slips upon the shaft, till equilibrium is restored. Twenty-four Julien accumulators are connected with the circuit as a regulator, and to keep the lamps lighted when the train stops. A centrifugal governor breaks the circuit of the accumulators when the speed slackens.

A third arrangement of electric car lighting is by accumulators on the train, to be charged by a dynamo at a central station or terminus of the road. In England, a Pullman train has been running some years, lighted by electricity supplied by accumulators charged when the train is at rest, by a dynamo driven by a gas engine. The Pennsylvania Railroad Co. experimented more than two years ago with accumulators charged at one end of the line. When the train arrived at Jersey City, the trays containing the cells were removed from the car to a charging room, their places being supplied by spare cells previously charged. The empty ones were charged, to be replaced in the first car needing its batteries changed, and these in turn to some other car. The changing of the cells in a car took about 10 minutes. These experiments were in the main satisfactory, but the weak point was the life of the cells, the plates of which after a time buckled and fell to pieces. These cells were furnished by the Brush Electric Co. for these experiments; but they declined to send out any more to be used in the same way until the Pennsylvania railroad experiments should be ended.

The estimated cost of fitting a car with ten lamps and batteries for 70 ampere hours was about $300 per car.

In the month of January of the present year, the Julien Electric Co. placed 60 cells of their accumulators in boxes, on car No. 90 of the Boston and Albany Railroad, and put ten 16 c. p. lights in the car. These proved to be insufficient and the number was afterwards increased to 24, of which 20 were on the car and four over the platforms. This car was run some two months, as an experiment, with such excellent results that in March and April the trains leaving Boston and New York at 4:30 P. M. every day were fitted up with the same system. (These trains are also heated with steam from the locomotive, and there are no fires or oil lamps in any of the cars.) Each coach and parlor car is fitted with twenty-two 16 c. p. incandescent lamps, of which two, are over the platforms, 16 in the body of the car and the rest in the vestibules and toilet rooms. The lamps in the car are arranged opposite each other in two rows in the top of the car, and are on two

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circuits entirely independent of each other, each of which has a switch of its own by which the lamps may be turned on or off. The platforms are so arranged as to be lighted from either end of the car. They may, if desired, be lighted only just before reaching a station and extinguished just after leaving it.

Sixty cells of Julien accumulators are arranged in boxes under the car, 30 cells on each side. The weight is about one ton. The boxes are neat and ornamental in appearance, and the 30 cells on each side of the car are entirely independent of those on the other side, and are separately wired as far as the switch-board.

The cells have a capacity of 150 ampere hours and 60 volts on each side of the car. As 60-volt lamps are used, the accumulators on either side of the car will run all the lamps, but of course for only half the time the whole will do it. They are arranged in trays of six cells each, furnished with handles; they weigh 200 pounds and can be raised from the ground and put in the car by two men. The trays are fitted on the outside with stiff brass springs, which, when the trays are in place bear against each other, and form the connection between each tray and the next. When the trays are in place in the boxes the connections are all made. There are, therefore, no wires to disjoin or connections to make when it is desired to remove a tray for examination or otherwise. From the boxes on each side of the car, wires are carried underneath the car to a switch-board in one of the toilet rooms, which also receives the terminals of the lamp circuits. The switch-board is so arranged that the number of cells in use can be varied from 27 in series to 30 in series, the others being added from time to time, to keep up the candle-power of the lamps, as the E. M. F. of the cells falls. Experiments are now being made to do away with the necessity for this, and if it is found practicable, it will be discontinued.

Two terminals underneath the middle of the car on either side serve to connect, by means of plugs, a pair of cables connected with wires leading to a dynamo in a lighting station a little way off. These terminals are of different size, so that no mistake can be made in the connections. When the accumulators are charged the whole 60 cells are placed in series; when they are connected to the lamps there are two series of 30 cells coupled together. In order that there should be no confusion or errors in doing this, I designed a switch which should, by a single movement in one direction, of four levers coupled together, throw all the cells in se-

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ries and connect them to the dynamo circuit. In this position they are entirely detached from the lamp circuits and no current can pass to the lamps. When this switch is thrown in the opposite direction the cells are cut off from the dynamo, coupled in two series of 30 cells each, and connected to the lamp circuits, which, however, do not light until turned on by the special switches for that purpose.

It is quite unlikely that an accident to either of the lamp circuits or the batteries on one side of the car would disable the other. By turning out the lamps on one circuit, therefore, the others may usually be kept burning till the train arrives at its destination. In two instances this arrangement of circuits has proved very valuable.

All the cars, except one, are fitted with Weston incandescent lamps said to take 1.1 amperes. The remaining car has Edison lamps, which are proving so satisfactory that it is quite probable all new work will be equipped with the Edison apparatus.

When the train arrives at Boston, it is put on a side track near which a line of poles has been set, and the dynamo wires strung upon them. Opposite each car a pair of terminals serves to make connection with the car, and the charging begins. A current of 18 amperes is run in for several hours, dropping to 12 and sometimes 10 amperes towards the end of the charge, which is now 180 ampere hours, to the 60 cells in series. If there were no loss, we could draw out 360 ampere hours in the lamps. Assuming that the lamps use 1.1 amperes each, we actually use about 22×1.1 ampere $\times$ 9 hours = about 216 ampere hours or 60 per cent. of what is put in. If the lamps are required an extra hour or two, there is plenty of reserve for them. [Note B.] The attempt was made to reduce the charge to 140 or 130 ampere hours, but as some of the batteries were not in first-class condition, the results were not good.

The intention is always to have surplus of current in the battery. For the present the trains run a round trip to New York and return with one charging, but it is not yet quite certain that it can be done in the long nights of winter.

NOTE B.—Mr. A. Reckenzaun in a recent article on storage batteries gives the average efficiency as not less than 70 per cent. The Julien company claim, I understand, 80 to 85 per cent. for theirs. Doubtless this can be realized under special conditions, but my own experience would not warrant me in assuming so much in car lighting,—at least until the most favorable conditions of use are better understood.

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The cost of fitting these cars with accumulators and lamps was, when complete, about $900 per car. Others fitted in the same way would cost less, as on this work the men were all inexperienced and there were no plans or precedents. The cost of operating the lights is not far from $2 per car per day, or about one cent per hour per lamp. When the lights are needed a longer time, as in the dark days of winter, the cost per lamp hour would diminish. This is about ten times that of oil, and very nearly the same as for gas, but taking into consideration the amount of light obtained, electricity is the cheapest of the three, and immeasurably the most convenient. The light is very brilliant, well diffused, steady, and satisfactory beyond all expectations. A very noticeable feature of these cars is, the entire absence of heat, and the purity of the air, which is as fresh and sweet in the car at the end of its trip as before it leaves the first station; this, together with the absence of danger from fire, especially commends it for sleeping cars. The Electrical Accumulator Co. have also lighted some cars with success, for the Fitchburg and Old Colony Railroads, at Boston.

The electric light has come to stay. It is the only one which anywhere near fills the conditions of a satisfactory light for railway trains. It can be readily adapted to almost any conditions to be met with in practice.

Oil lamps, and stoves in cars, must follow where the old couplers and hand brakes for passenger trains have gone in this country, until electricity and steam heat have made the roasting alive of scores of people pinned fast in a railroad wreck as impossible as the air brake and Miller platform have made the telescoping of a train into a shapeless mass of ruins, as happened formerly so often. Not many years hence, we may well hope, one will be as uncommon as the other.

DISCUSSION.

THE PRESIDENT:—The paper is now before the meeting for comment, criticism and discussion. Mr. Blodgett has had, as you have heard, very practical experience with the work and will be happy to answer any questions which may be put to him in regard to any of the details.

THE SECRETARY:—I had the pleasure of coming from Boston, a week ago to-night, in a train equipped with the system which Mr. Blodgett has described so successfully, and having in view the fact that this paper was to come before our meeting, I per-

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haps gave the lights more attention than I otherwise would. The first and most noticeable feature of the installation to my mind was the fact that it appeared to be permanent. It was not experimental in the sense that so much electrical lighting has been, which we have all seen. Wires may have been there, but they were not visible. The lighting of the cars was certainly the best general lighting that I have seen with the exception, perhaps, of the Electrical Exposition at Philadelphia. The cars were lighted up in the station before leaving Boston at 4.30 in the afternoon, as it was rather dark in the building at that hour. That was the first advantage I saw. Although early in the summer afternoon, when artificial light is usually unnecessary, it was very easy to turn the lights on to give good illumination while the cars were temporarily in the station. After leaving the station, they were turned off, not being required again until nightfall. I think we reached the darkness about Hartford, and not having the scenery to gaze on, I turned to a book I had with me, and was very much pleased to find I could pass the time pleasantly with reading, without any strain on my eyes; and one curious feature of it was that, being absorbed in my book and having been looking out of the window for three or four hours, I turned once or twice to look out, and was surprised to find it was dark outside; there was nothing to look at. I had almost lost sight of the fact that it was artificial illumination, and this was certainly a very pleasant feature to think that I could read by a light as perfect as daylight, and possibly more perfect than some daylight that is quite common on the other side of the water. The lights are turned on in going through tunnels, or when you come to dark stations, which I consider a very desirable feature. The element of safety is one that is particularly noticeable, because we have heard so much of the dangers of fire from electric lighting. Now, however, when it comes to requiring safety from fire on railway trains, our experts turn to electric lighting, as the only resource; and there is no doubt but that danger from fire is entirely eliminated by the use of incandescent lights from storage batteries as they appear on that line. I am contrasting the wiring of this installation very favorably with another installation of car lighting which I saw on the same trip, where the wiring in both baggage and passenger cars bore evidence of having been done by some bungling telegraph lineman who had just started in the business. The expense the Boston and Albany Railroad Company has incurred in introducing

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these improvements reflects a great deal of credit on the progressive management of that road.

THE PRESIDENT:—I would like to ask Mr. Blodgett a question. You stated in the course of your paper, Mr. Blodgett, that the cost of electric lighting was ten times that of oil. I would like to have it specifically stated, if you can do so, whether that applies to the whole of the apparatus or simply to the service.

MR. BLODGETT:—My figures in relation to the cost of oil lighting were taken from a report by the Master Car Builders Association—possibly ten years ago. My impression is that in this report they took into account only the actual consumption of oil for lighting, and that no account was made of the cost or the care of the lamps or their renewal, or anything of that kind. Their figures show that oil lighting costs about one-tenth of a cent per hour. As near as I can estimate from our own experience with electric lighting, it is not far from one cent per hour, which would be, roughly, ten times the cost of oil lighting, not counting the cost of the renewal of the plant, or as my impression is, the cost of repairs to oil lamps—I am not certain about that.

THE PRESIDENT:—As I understand, the cost of electric lamps in a car is materially less. I am speaking of the lamps themselves. Is not that the case?

MR. BLODGETT:—The fitting of the car with oil lamps, will cost anywhere from $12 to $50 for each lamp, and if, as is usual, from twelve to fifteen lamps are put into a car, it would cost not less than $150 for the oil lamps put in a car. The cost for an equal number of electric lamps would not be over $24.

MR. PHELPS:—May I ask Mr. Blodgett, in making up the figures of cost of electric lighting, if he first entered the item of depreciation of the storage battery plant—its consumption?

MR. BLODGETT:—It is difficult for me to estimate to just what that would be. The assumption was made that the batteries would last two years.

MR. PHELPS:—Then your figures proceed on that basis, the renewal of the batteries in two years?

MR. BLODGETT:—I think that was the estimate; renewing them every two years. I ought perhaps to say, regarding these figures, that the time during which the apparatus has been operated, is so short, that the figures are only roughly approximate. The cost may prove to be very much less than this, and possibly, but not probably, is seems to me, somewhat greater.

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MR. RIES:—What proportion of the cost for lighting is due to the cost of handling the batteries, and what proportion is due to the interest on the installation?

MR. BLODGETT:—There is no expense for handling the battery. The charging of it has been done thus far at the rate of seventy-five cents per car per day. I think it will cost somewhat more in the future, as the electric lighting companies who are doing it, complain that this rate does not pay the cost. Possibly it may cost $1.50 a day per car for the charge.

MR. RIES:—According to that, the cost per lamp simply for the charging, would be about five cents?

MR. BLODGETT:—Roughly that.

MR. BRACKEN:—I can state that the cost of charging Julien cells per car is about thirty-three cents. The Weston Company charges one dollar and a half per car. I may say here that about six or seven days ago I met Mr. Pullman. I remarked, among other things, that the chief objection to lighting railroad trains by electricity seemed to be the expense, and he said—of course it was his opinion, but it has considerable weight, coming from a man of his experience—he said that the mere matter of expense would not stand in the way of ligthing by storage batteries, if it were proved to be practicable. Then we have the opinion of another gentleman who has had a great deal of experience, Dr. Dudley, of the Pennsylvania Railroad. Two years ago, that road experimented with storage batteries. Dr. Dudley has come to the conclusion, as a result of his experience, that the only thing now wanting to induce the Pennsylvania road to adopt the storage batteries was a simple connector of a cell whereby a plate could be removed which showed any disposition to deteriorate. So far we have been unable to get a connector that we could remove and adjust without considerable trouble in order to remove a defective plate. The chief objection made by parties in relation to lighting by storage batteries is the fact of cost—the first and the only objection; but experienced railroad men, as I have told you, do not seem to regard that as a serious objection any more than is the cost of a parlor car in comparison with an ordinary passenger car.

THE SECRETARY:—I would like to inquire whether the objection to the expense is on account of the original cost of the plant or the cost of the running of it, after it is installed?

MR. BLODGETT:—I think, Mr. President, that both those arguments have been used as an objection to the introduction of elec-

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tric lighting; but if account is taken of the amount of light furnished by the electric light in comparison with gas or oil, that item of expense will disappear. If people will be content to have as little electric light as they will get from oil or gas, the expense, it seems to me, would be no greater, but the change in lighting is the excuse for getting three or four times as much light as is furnished by the old systems. In that respect the cost of electric lighting is made to assume a very undue proportion in relation to the cost of other methods of illumination, and there, it seems to me, is a very prominent reason why the electric light fails to make greater progress—that with the change, is demanded an enormous increase of light.

MR. LOCKWOOD:—Mr. Blodgett, among other statements in his paper, remarked upon a method of introducing first, only a comparatively small number of cells, and as exhaustion supervenes in those cells, a few more are introduced, and then a few more. I would like to ask him whether experience has demonstrated that to be a better method than introducing the full number of cells at first and with them a certain artificial resistance, and then switching out the resistance as occasion would demand?

MR. BLODGETT:—I would say in answer to the question that the number of cells was never varied more than four on each side. We started with twenty-seven cells in series and ended with thirty in series. We have run trains on trips with the whole thirty cells in series, and I might say with substantially the same results. There was no opportunity for me to determine by experiment, previous to running these trains, any of the questions which have come up in relation to it. The electromotive force of charged cells is rightly two volts, but when they are freshly charged it is somewhat more than that; I think some of the publications on the subject state it at 2½ volts. In order not to have the undesirable effect of burning out a number of lamps by running a greater current than they would bear, this arrangement of switches was made. Thus far we have no unfavorable results. In one or two instances, when that was tried, it did seem to me as though the lights were not quite so good at the end of a trip as when we had started with twenty-seven cells in series, and four remaining cells to be put in from time to time, as the candle power of the lamps began slowly to diminish; but I am not prepared to speak decidedly on that question either way.

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MR. LOCKWOOD:—Does not the resistance of the cells vary as their E. M. F. runs down?

MR. BLODGETT:—I think that is probably true.

MR. LOCKWOOD:—That is the point I was trying to get at, as to whether it was a decided advantage to keep those cells included in the circuit, even though they were to a certain extent exhausted, and even though you got the benefit of the new cells by so doing.

MR. BLODGETT:—I think further experiment is necessary in order to enable one to answer that question.

MR. MAILLOUX:—I think I can give some information on that subject to Mr. Lockwood. I hardly think the question needs to be answered, because probably everyone who has experimented with primary batteries, knows that you can take freshly charged bichromate cells—say Fuller cells, and if you wish to make a constant difference of potential across a certain part of the circuit you can use a part of them at first, and as they weaken add more to the circuit. The only difference that it makes, as far as I know, is that you are adding cells which have not been worked so much, and they would not give out so quickly as the others. In others words, the number of ampere hours that would be obtained from these freshly added cells would not be so great, and in practice, using them, as Mr. Blodgett states, those cells that are added last are never discharged to such an extent as the others, consequently there is some energy left in them at the end of the trip. It would doubtless be practicable to use resistance as Mr. Lockwood suggests, and to discharge the cells, but there would be nothing gained by it, except, perhaps the inconvenience of handling the resistance. It is much simpler to use only those cells which are necessary to get the proper electromotive force, and to add cells as the electromotive falls down; and those cells which are put in last if they are not fully discharged, are in much better condition because we find in working storage batteries that it is not well to charge a storage battery too much. Indeed, I may say that the greatest grievance we have against storage batteries, is that the public will insist on trying to give to the storage battery a greater capacity than the maker himself would like to have it go out for. The Julien Battery Company, with whom I have the honor of being associated, makes a cell of one hundred and twenty-five ampere hours, which is catalogued for that rate; but we find numerous people who have endeavored to use it for street

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car traction and for various other purposes, and who have come to us telling us that they get from 180 to 200 ampere hours out of the cells, thinking they were giving us very valuable and much coveted information. But while we admire their enterprise, at the same time we always deem it prudent to tell them that they really need not fully exhaust their cells, that they had better restrict them to the capacity which the manufacturer denotes. We tell them, if they persist in using a 125 cell to a capacity of 180, we shall have to rescind the guaranty of two years that we give upon a cell. The fact of the matter is, that there is an intimate connection between the life of a cell and the way in which it is handled by the person who buys it, and, as I just said, the trouble comes mainly from the fact that the cells are over used. It is not the use of the cell, but it is the abuse of it that is always responsible for its giving out. As long as a cell is not fully discharged, the peroxide on the positive plate is to a certain extent infiltrated with sulphate that has been produced by the chemical reaction during discharge. But if we proceed so far that a large quantity of sulphate becomes formed at the expense of the peroxide, then we shall find that when the process of discharging is again resumed, that we can no longer reconvert that mass of sulphate into peroxide, and wherever the process of charging is stopped, there will be a process going on by which that sulphate will undergo a fresh reaction and become hardened, and the consequence will be that a line of demarcation is produced and a scale results. That scale is the beginning of trouble and a great many times the beginning of the end with a great many storage batteries. This is a defect which is inherent in a great many storage batteries using lead. Now, if we do not discharge the battery too much, we leave a sufficient mass of peroxide to add conductivity to the mass of sulphate, so that the process of discharging can proceed without difficulty. That is why it is more difficult to use the three or four cells which are added, and which are necessary to rejuvenate the force of the rest than to discharge them all equally. Those three cells are not discharged so much as the others, consequently they are not so much used, and, by the process of changing the trays once in a while, so that they all have this little holiday at the end of the trip, the amount of life thus given to the battery could be averaged through the whole number of them.

MR. WETZLER:—Mr. Blodgett, in his paper, enumerates the

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different methods by which trains may be lighted, and in all of them except one, in connection with which he mentions the primary battery, we find that where we want a steady light the storage battery must be added to the equipment. Although he says he has had experience with only one of this kind, I would like to ask if he has formed any opinion upon the ultimate shape which the application of the storage battery will assume—whether it will be charged on the train or whether it will be charged at the terminus only.

MR. BLODGETT:—That is rather a hard question to answer, since it must be on my part merely a matter of opinion. It does seem to me, however, that some one will find a way by which the battery can be charged on the train with regularity and with good results. If that can be done, it will much simplify the use of the storage battery, since the charging will take no extra time, and would, it seems to me, give better results than being obliged to charge the batteries every day or every other day. I know of no practical device at present to accomplish that result. Its success in England is due to the different arrangement of the cars. Most of the English cars on which it has been tried, have, in place of our trucks at either end of the car, only a single axle and a pair of wheels which are fixed with sufficient rigidity, so that they can run a dynamo shaft. But American cars have a swinging truck at each end from which it is difficult to convey power to any other piece of machinery while going around curves.

MR. RIES:—Mr. Wetzler has asked almost the same question that I was about to propound, and Mr. Blodgett has answered it so far as the present state of knowledge is concerned. But the feature that Mr. Blodgett just mentioned: namely the difficulty of making connection between the axle and other mechanism is, of course, one of those difficulties which only time can overcome. But it seems to me that instead of taking a secondary battery, instead of equipping in such a way that the battery must either be removed from the car, or that the car must be side-tracked and remain idle for eight hours more or less, a system could be devised in which the battery carried by the car was a permanent fixture and received its charge during the time that the train was running on down grades by a dynamo, driven by the surplus energy of momentum of the train itself, whereby the direct application of steam co-operating with the dynamo can be obviated. One of the greatest objections to these various steam

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heating systems, is that in order to maintain a separate system of heating, the locomotive would have to be drawn upon very considerably, and that is found somewhat impracticable. The very same objection would obtain in the use of a battery; but on large trunk lines, there are numerous trains in which it would seem that the momentum which is in excess of the speed at which it is desired to run could be readily converted into chemical energy, which could be stored in a battery until required. It might be so arranged as to receive all the current that is generated at regular intervals, and in a simple way this could be made to furnish the current for lighting. Several of the members here would be pleased to know whether Mr. Blodgett has had any experience with such system, or whether he knows of any such system being proposed for utilizing the electric current for lighting railway trains.

MR. BLODGETT:—I do not, Mr. President, know of any such system. It seems to me that the amount of power required to light a train electrically is so very small that it would not be a serious question. If the locomotive is so nearly worked up to its full capacity that it could not spare two or three horse-power more when running between six hundred and seven hundred perhaps, or possibly eight hundred or nine hundred horse-power, if it could not spare two or three more for lighting the train, then it would be necessary to attach a second locomotive to keep up the speed of the train around the curves. The belief that the heating of the train would make a draft on the locomotive has been brought up as an objection, but practical experiments have failed to show that steam heating does have such an effect. The amount of steam heating required for a train is very small, and the pressure of two to five pounds even in very cold weather with proper piping of the cars and proper connections, will sufficiently heat the train, and when the locomotive carries 160 pounds steam, as the best kind of locomotives do, a pound or two more is not a serious percentage of loss.

MR. LOCKWOOD:—I am very happy to add my little word of testimony to that of Mr. Pope, as to the efficiency and perfection of the system of electric lighting which now obtains on the afternoon train, between here and Boston. It is some three months since I first travelled on that train, since the lighting and steam heating was introduced, and although I had heard it vaguely referred to in the papers, I had not experienced it myself

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before that; and it was with considerable doubt that I took my seat on the train that afternoon. Mr. Pope has remarked upon its advantages in going through tunnels. I must say, there is room for difference of opinion in regard to that. But as there are not many tunnels between here and Boston, it is not much of an objection nor much of an advantage upon that line, but it is a real pleasure to any one who likes to read upon the train, or who likes to see what his fellow passengers are doing, or who likes to eat intelligently, to travel upon a train lighted with incandescent electric lamps excited, not necessarily by a Julien battery, but by any good secondary battery. I notice with some grief that the gentlemen here have been persistently calling such batteries accumulators and storage batteries. There perhaps may be a word or two which might pertinently be said referring to the English installation, which Mr. Blodgett has mentioned. The system which is in use on the London and South Coast Railway is, as as we have heard, operated by the shafts of their cars, and, as Mr. Blodgett has said, they do not use trucks at all, simply a pair of wheels on each axle. The method of getting the power to the dynamo is by using an counter-extra shaft and running two belts. That is a point worthy of notice—a pulley on each side of the train, running two belts to the counter-shaft, and although it was not done so at first, they have recently adopted also two belts from the counter-shaft to the dynamo axle, putting the pulley on both ends so as to insure running at all times. They also have a very ingenious method of keeping the belt stretched by screws at both ends, both operated by one handle by means of a worm gear which pushes the counter-shaft into a position diagonally to or triangularly from, the dynamo axle and from the first main axle of the car, so that it tightens up both series of belts, at the same time. It seems to me there is something which is more theoretically perfect in such a system, which carrying the original power along with it, may also carry and excite batteries, to maintain the light when the dynamo is at rest, than there is in any other system. Of course, the objection that is stated against that in this country is very weighty; but I think the time will come when our cars, as well as our houses, our stores, and our business blocks, will be properly fitted for the use of every electrical appliance, with, I hope, one exception. While we want all the light we can get while we are travelling (except in tunnels,) we do not want, at least I do not want, ever to be

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telephoned to, or to telephone a message, or to be telegraphed to, or to send a telegraphic message to anybody while I am on the train. I think, all who have to work as hard as you do, will agree with me on that point. The steamship or the train is now our sole refuge. (Laughter and applause.) We want at least one haven of rest where the wicked will cease from troubling. One gentleman questions in some degree, whether using the power of the locomotive to operate the shafts of the dynamo would not detract somewhat from the tractive power of the locomotive. Mr. Blodgett answered it very well, as I thought; but that question appears to have already settled itself, when we consider the English method of getting light on a train. I read very carefully the paper written by one of the inventors of that system before the Institute of Civil Engineers in London on that point, and, while it may be that he is wilfully disguising the truth, he being an inventor, yet it is a fact that he says nothing about any such loss of power, if it occurs. He does not seem to intimate that the locomotive goes any slower between London and Brighton, or that it uses any more coal, or that it uses any more steam. It may be that it does. At all events the locomotive does not appear to feel the extra strain upon it at all. It gets there just the same. Without any disposition to criticise, I notice one statement of Mr. Blodgett that was very interesting, yet I do not know that it completely covers the ground. He remarked, when discussing the difference of cost, which seemed to be considerably in favor of oil over electricity, that the amount of light which we used to have under the old oil administration, before Mr. Cleveland was elected, (Laughter) was not half as much as we get now. Well, we all know that is true. We did not get one-half or one-tenth as much light as we get now. It was worth one good pair of eyes to try to read for ten miles. But in view of the fact that when we get a certain amount of light from a certain amount of electrical power, it takes a very little more electrical power to bring the light up to a much higher degree of brilliancy, it is a question with me whether, if we brought the light down to the old standard, the cost would be very much diminished. I rather doubt it.

MR. BLODGETT:—It may be, Mr. President, that I did not make that part of my statement sufficiently clear. I meant to be understood as saying that, if we put in lamps enough in a car only to light the car to the same degree of brilliancy that was obtained by oil, then the cost would be no more than that of oil; not by

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using the same number of lamps we are at present using, but by putting in a less number. It is true that, if you decrease the candle-power of the lamps, you use a larger proportion of energy to produce that candle-power—a larger proportion per candle-power than if they are running at a higher candle-power. But using a less number of lamps and lighting the car the same as it was lighted with oil, the cost, I think, would be no greater than with oil. We ought to consider that, in a lamp of say sixteen candle-power, perhaps one-half of the light and perhaps a larger portion is cut off from available use by the fixture of the lamp itself. In the electric lamp there is no fixture to cast a shadow or absorb the light, and withdraw it from a useful purpose.

MR. LOCKWOOD:—I am very glad to get that explanation. The last paragraph of this most interesting paper reads as follows:

> Oil lamps, and stoves in cars, must follow where the old couplers and hand brakes for passenger trains have gone in this country, until electricity and steam heat have made the roasting alive of scores of people pinned fast in a railroad wreck as impossible as the air brake and Miller platform have made the telescoping of a train into a shapeless mass of ruins, as happened formerly so often. Not many years hence, we may well hope, one will be as uncommon as the other.

A great English poet once said: "Hope springs eternal in the human breast." And I am quite sure that if we get all the incandescent lamps that we can, and light our train as brilliantly as possible, and leave out the stoves, that the railroad companies will still find some way to get square with us. They will put bridges askew or build tin bridges where iron bridges should be placed.

What I wanted to mention was that there are people to whose perversity I feel that I cannot do justice. I refer to the person who deliberately pulls up his window on a dusty day in front of you, and in that respect I must say our English cousins who are generally behind us are ahead of us. Not only did they start train lighting long before we did, and run it to a greater degree of perfection than we did, but they are using the window which we are now using for street cars. Now if car builders will adopt that sort of window so that we could lower it instead of raising it, it would do away with the blasphemous thoughts which arise in our breasts on many occasions.

MR. WETZLER:—Mr. Ries has led the discussion in a direction which I think would still bear pursuing a little further. He refers to the fact that where storage batteries are used on trains,

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some account should be taken of a method by which trains running down grade shall be enabled to charge batteries; that these means must to a certain extent be automatic seems self-evident, and I believe Mr. Ries's modesty is such that he has withheld something from us that would shed some light upon the subject. I would, therefore, like to hear his views on this question.

MR. RIES:—In respect to Mr. Wetzler's kind suggestion, I would state that while not fully at liberty to mention what he undoubtedly refers to, I might say that I have given some attention to this matter of accumulating the surplus energy of a train and storing it in the form of electrical energy, and among the problems was the one that Mr. Blodgett suggested in reference to the axle of the car, which I believe we have solved. There is also another objection, and that is, that as the speed of the train slackens, naturally, the electromotive force of the current produced decreases and means must be provided for maintaining that up to the standard, so that the batteries will not discharge through the generator. There are other matters which, of course, suggest themselves in this connection, but we might say in a general way this: Taking the ordinary trunk line road, we find a great many with very steep gradients; the energy of the locomotive used in propelling a train up a steep incline is ordinarily wasted on the next descending grade by the energy of the train being checked and further steam applied to check it by means of the brakes. Now, the energy of a train can as well be checked by attaching a generator to the axle directly or by means of belts, the direct connection being preferable, and forcing that to generate more or less current. In order to accomplish this I have devised a form of pendulum switch—or any other form of gravity switch will answer—whereby the amount of current produced by a generator for charging the battery is directly proportional to the inclination of the grade; so that as long as the train is running on a level the field magnet coils of the generator are open, and the magnetic saturation can be increased or diminished at will. The number of coils thrown into the circuit is automatically adjusted by means of this switch before mentioned, whereby, when the train is running down on a steeper incline than before, it makes a stronger magnetic field, retards a greater proportion of the energy of the train and generates a correspondingly increased volume of current which is stored in a battery for use as required. Now, the greatest expense in the present method of lighting railroad trains by

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batteries seems to be in the cost of charging. A further expense in some systems arises from the fact of using a double set of batteries, one of which is being charged while the other is being worked—both of which can be dispensed with—as well as the cost of handling. By means of a system of this kind the battery when once in position is self-charging, so to speak. A sufficent number of cells are used to give you the requisite number of ampere hours, and the number of cells that we do use, of course, will be determined by the number of hours that your train is running. The generator is so arranged that, as before stated, in running on a small incline, the field magnet strength is slightly decreased, but as the speed of the train slackens, in case of wanting to come to a stop, the field magnet strength is automatically increased. We have both a gravity switch and governor in this arrangement, so that the electromotive force is produced until the speed of the train has very nearly ceased. In that way the battery will always have a sufficient supply of current in reserve, whether it be used for lighting or braking or whatever other applications you may wish to employ. The system, of course, is as yet somewhat incomplete, but is being developed, and I hope at some future time to go more into detail in regard to it.

MR. MAILLOUX:—As those who have preceded me remarked, we have in this branch of the discussion a most interesting and perhaps timely topic, and I can state here, semi-officially that the Julien company is, and has been for some time actively engaged in the study of that very question. I have had several communications upon the subject from Mr. Julien, who is now abroad, besides having given a great deal of attention to the matter myself.

I must say that I do not quite agree with Mr. Ries, in his views on the subject of utilizing only wasted energy. This idea of using waste energy is very good in theory, but it does not always work in practice. A car starts from here to go to St. Louis, or some distant point, a trip requiring a considerable length of time. Now, what a practical lighting man, like Mr. Blodgett, wants to know is, how many hours of artificial light will be required; how many lighting hours of electricity he has got to supply that want, and with him it is of far more importance to be able to get at so many ampere hours per mile, than it is to take his chances of getting it at the next grade, or giving the engine a spurt so as to get it on going down a grade. Therefore, I believe that as the

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amount of energy which is constantly being drawn upon, in a car making a long trip is so small, that it will be better in practice to content ourselves in drawing it directly, without paying attention to what is being saved or to what might be saved. In a car travelling all day, it is safe to say that excluding the time of stoppages, we have something like twenty or twenty-two hours of travel. Now, if we so arrange the apparatus that we can draw a small current for those twenty-two hours, it is quite evident that the draft might be large, and as Mr. Lockwood, very aptly remarked, doubtless the strain on the constitution of the iron horse might be very appreciable. On the other hand the hours of lighting will never be so long, because in sleeping cars after certain hours there are very few lights in use. The policy which the Julien company has pursued has been to aim at simplicity and to so arrange apparatus that it can be put into the hands of whomsoever may be called upon to direct its application, and with that in view we have sought to eliminate as far as possible, all elements of complication in the way of regulating gear. Not long ago, I visited a train of which Mr. Blodgett spoke in his paper, in which the attempt is made to get motive power from the axle. I found, on arriving there, that the gentleman had almost converted the baggage car into a machine shop. He had very complicated machinery below, and upon entering the car I found that he had very complicated machinery inside. He informed me that the system worked very nicely indeed. I did not wonder. It ought to work beautifully with the amount of complication that he succeeded in introducing into it. But I doubt very much whether the average railroad manager, or superintendent, or master mechanic, or whoever the official is that is charged with the lighting of cars, would be satisfied to accept the introduction of such a system on his road. It seems also that on roads having considerable traffic it would be necessary for them to provide an additional baggage car, because there is no space left in the compartment in which the machinery is put, and it would be cheaper to go the whole extent, put in power, make the car a little smaller, and call it a lighting car.

The system at which, it seems to me, we should aim, is a system in which there is little or no complication. As you all know, the fact must be borne in mind, that a train will run anywhere from ten to fifty miles an hour. Now, in order to compass the great variations, consequent on such a change of speed, the minds

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of electricians have been filled with numerous devices of resistance regulators, etc. Now, I do not see that any system involving the application of complicated regulating devices of that kind can hope to be successful. We must have a system in which the mechanism is so simple that there are practically no details to it. If we can have a dynamo that will take care of itself, we are working in the right direction. I remember that at a previous meeting, during a discussion on electric street cars, Mr. Field remarked on the sparking of the dynamo, that he proposed to let the sparking take care of itself. Now, I think that is the keynote of what we should do in the lighting of cars. Undoubtedly the day of lighting cars with an axle dynamo is coming, and when it has come, we shall find that the proper system is that in which the dynamo is taking care of itself, without having to call upon a thousand and one details of machinery and clock-work to assist in taking care of its work.

MR. RIES:—Mr. Mailloux made a very forcible argument in support of the direct dynamo connection for generating purposes. I fully agree with him, that that would be the simplest as well as the best system to adopt in practice on such roads where for certain reasons the momentum system suggested before would not be applicable. But it is a well known fact that a great deal of power is lost every day on our trunk line roads, from the very cause mentioned, and the secondary battery presents to us a useful and simple means of converting at least a portion of that energy into use. Now, I do not advocate this system on level or substantially level roads. It is only in cases where the advantages would justify its adoption that I would recommend it. For ordinary roads, however, the direct dynamo and battery connection as recommended by Mr. Mailloux, is perfectly proper and probably the best plan to adopt.

MR. PENDLETON:—While listening to the remarks on the accumulator and the care with which it has been attempted to work out a system, simple and effective, for the purpose of lighting railway cars, I failed to see where there is, in the necessities of the application, room for very great study. The principle of the accumulator is that one ounce of material will hold a certain quantity of chemical energy. That was the feature of the Faure battery of 1880, and as nature is generally regular in her habits, we may calculate that one ounce in 1880, of peroxide of lead would hold as much nearly, as it will at the present time. There have

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been certain improvements made, however, in the accumulator, of decreased resistance, and capacity increased relatively to the weight of the battery; so that at the present time there is improvement, but the basic element remains the same. The feature in the storage battery appears to me to be one of inherent character which is difficult to overcome, except by the intelligent application which Mr. Blodgett has to-night mentioned of switching in additional cells. We all know the effect if the electromotive force of the battery fails to be discharged. There is another and unfortunate effect, in that the resistance of the lamp is also increasing; requiring some means of keeping up the electromotive force and keeping down the resistance of the incandescent lamp. Some years ago that feature troubled me considerably, as to the application of storage battery plants for general use, and I felt that the storage battery when applied would find its great use in power, in the application to street cars, in the application to motors, etc., and which is now being developed to an extent which makes the subject very interesting. We have seen in our streets a car, the mechanical construction of which being completed in a foreign country was not exactly suited to our railways. I do not know whether it has yet been brought to a point of perfection. But at any rate, competent electricians riding on the car stated that the defects were purely mechanical and that the electrical performance of the car ought to satisfy anyone informed upon the subject of electrical work and the action of the motor. A number of cars are being built, and what was a dream among electricians, six or twelve months ago, will very shortly be in practical use. Railroad men generally are very slow to take hold of improvements in their different systems. So many unfortunate experiments make them weary, and it is only after most thorough and careful tests that they are disposed to adopt new devices.

In the matter of lighting cars by electricity, I think Mr. Mailloux is at fault in stating that it has not before been accomplished in this country. I recollect the Pennsylvania Railway Company making experiments in 1883. I paid but little attention to them. I know also that in England in 1882 the London and Brighton train was lighted by accumulators, and so continued for several years and may, for all I know, be so lighted at the present time. There is nothing new in the matter. The fact has been demonstrated that the Julien battery is a well manufactured, good accu-

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mulator for the purpose—as good as any that is made. The claims for efficiency are high. I hardly believe that it is intended that 85% as claimed is the efficiency of the battery. I know of recent tests made where the efficiency, the return of power, was determined to be 65 per cent. and was considered very satisfactory. I certainly found it so, because it proved a belief that I had that the true efficiency of an accumulator was 50 per cent. I recollect at a former meeting of this society when I stated that fact, it was doubted. With 65 or 66 per cent. return from the battery, and allowing 15 per cent. loss in the motor; this 50 per cent. efficiency is realized in the use of the storage battery for propulsion purposes, and as the tests were made under the supervision of your late president, Mr. Pope, I know that they are thoroughly reliable. It is a return that must bring the battery for the purpose of propelling cars into very general use, and I know already of several cars being built for the purpose of testing the matter.

MR. MAILLOUX:—I would like to make a few remarks which it would be well to place on the record in this connection, as Mr. Pendleton, my friend and esteemed colleague, has made some remarks which refer to the Julien battery of which I am one of the representatives here. With due respect to Mr. Pendleton, I must say that he likes to live in the past. He has been pleased to go back to the time of Faure and tell us that an ounce of active matter was capable of storing a certain amount of energy. I would like to take him back further, to the time of Plantè, and show him that an ounce of matter also had the power to store a certain amount of energy, and I may even go further back than that. An ounce of matter in a storage battery—peroxide—is capable of holding a certain amount of energy. Now, with regard to the efficiency, I would like to call the gentleman's attention to the fact that efficiency in train lighting is quite a different thing from efficiency in the case of motor traction; and as I told him at the meeting where we had the discussion on electric motors, it is quite important to take into consideration the successive transformations that the energy has to undergo. It is necessary that we should know where the final absorption of the energy takes place. If we are going to take the energy and transform it several times, each time we have to take into account a coefficient of loss which he fails to take into consideration. I think we can easily show that the efficiency of electrical energy in lighting is much higher than 65 per cent. It is true that there is nothing

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new with regard to the application of electricity to train lighting, using storage batteries or any other means. At the same time anybody who has studied the question realizes that there are many different conditions to meet, and that because it is not new, does not prove that it is undeserving of our attention. There are in it some problems which call for the highest knowledge of the electrician, and the highest skill of the engineer, and I think it is well to bear those subjects in mind.

THE PRESIDENT:—I think we have spent a very pleasant and profitable evening, and we are greatly indebted to Mr. Blodgett for the admirable paper he presented to us, and which has brought out so valuable a discussion.

There being no further discussion of the subject, I declare the meeting adjourned.

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